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ACTA RADIOLOGICA
EDITA IUSSU SOCIETATUM RADIOLOGICARUM
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VOL. 45 FEBRUARY 1956 FASC. 2

COMPARISON OF UROGRAPHY WITH SELECTIVE CLEARANCE AS TESTS OF RENAL FUNCTION

by

Nils P. G. Edling, C. A. Edvall, C. G. Helander and *B. Pernow*

The urographic signs of normal renal function following dehydration of the patient usually consist of simultaneous filling of the calyces on both sides, moderate distension and high density of the pelves and upper parts of the ureters upon application of ureteral compression, and bilateral emptying of the pelves and ureters after the compression is removed. If the examination provokes shock with a decrease in the systolic blood pressure to 70 mm Hg, contrast filling of the pelves does not commence, or ceases, and a nephrographic effect, due to accumulation of contrast medium, and of the same degree in both sides, appears. Following the raising of the blood pressure, excretion into the pelves proceeds.

These signs are usually easy to define in the films.

More difficult is the situation in hydronephrosis where one or both pelves are dilated, in diabetes with diuresis, or in old people in whom the normal density of the pelves is less than in the middle-aged and young. Another disturbance to a normally functioning kidney is the delayed filling of the pelvis with contrast medium and its accumulation in the renal parenchyma due to an increase in the intrapelvic pressure in acute obstruction to the emptying of the pelvis. In addition there are all the cases with locally or diffusely damaged tissue. In the case of local changes, it may be difficult to determine whether the contrast filling of the diseased part of the pelvis is primary or secondary; and in the pres-

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From the Roentgendiagnostic Department (Director: Prof. K. LINDBLOM), the Surgical Department (Director: Prof. J. HELLSTRÖM), the Central Laboratory of Clinical Physiology (Director: Assoc. Prof. T. SJÖSTRAND) and the Central Laboratory of Clinical Chemistry (Director: Assoc. Prof. B. SWEDIN), Karolinska Sjukhuset, Stockholm, Sweden.

ence of diffuse changes, the degree to which the renal function is impaired.

While the study of the function of the individual kidney in general ward service has up to now been based mainly on the roentgenologic examination, the study of the function of the total renal tissue has also been made clinically. The urographic findings may be correlated to the usual concentration tests, to the amount of non-protein nitrogen in the blood and to clearance tests of bladder urine.

As far as we are aware, no comparison of the excretion of contrast medium in urography with clearance tests on individual ureteral urine (selective clearance) has yet been published. This has prompted this account of such an investigation.

Physiology. Under ordinary conditions about one fifth of the plasma is filtered into the glomerular capsules from the arterial blood which passes the glomerular tufts. The glomerular filtrate is a simple ultrafiltrate and contains the non-colloid constituents of the plasma. During its passage along the tubules almost all the ultra-filtered water is reabsorbed into the blood, not more than one to one and a half liters being excreted as urine from the kidneys every twenty-four hours. Many of the constituents of the filtrate (glycose, chlorides, etc.) are also re-absorbed with the water. On the other hand, certain substances are either not re-absorbed or only slightly re-absorbed; also among the substances not re-absorbed by the tubules are inulin and the organic iodine compounds (Diodrast, Umbradil). Inulin which, in addition is excreted merely by glomerular filtration, is therefore used for the determination of the rate of glomerular filtration in the inulin clearance test.

Evidence exists that the renal tubules in man possess the power not only to re-absorb but also to excrete. Only a few unimportant plasma constituents are supposed to be excreted in this manner, but a number of foreign substances when added to the blood are excreted through the tubules. This is the case with the organic iodine compounds and para-aminohippuric acid (PAH) which are excreted through the glomerulus as well as through the tubules. The quantitative study of the plasma flow that passes functioning parenchyma — the effective renal plasma flow — and tubular function is evaluated by the Diodrast or PAH clearance test. At low plasma levels the Diodrast clearance is practically identical with that of the PAH clearance. As the chemical determination of PAH is simpler and as this substance also has other advantages, it is recommended as a substitute for Diodrast and Umbradil in laboratory and clinical investigations.

The ratio between inulin clearance (glomerular filtration) and PAH clearance (effective renal plasma flow) is called the filtration fraction and signifies the fraction of the plasma filtered through the glomerulus.

The glomerular filtration of Diodrast increases practically in proportion to its concentration in the plasma. The tubular excretion of Diodrast increases in proportion to its plasma concentration as long as this is below 5 mg/100 ml counted iodine (Diagram 1). If the concentration exceeds this so-called 'self depression limit' the tubular excretion decreases relatively in comparison with an increasing plasma concentration. At a level of 25 mg/100 ml iodine in the plasma, the tubular excretion reaches its maximum and remains constant in spite of higher plasma concentrations (SMITH, GOLDRING and CHASIS 1938). JOSEPHSON (1952) has especially studied the excretion of Umbradil injected in large amounts.

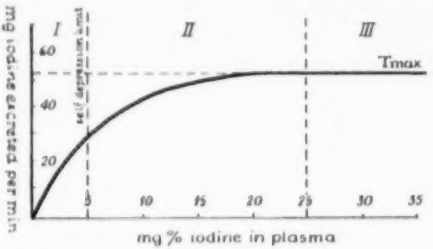


Diagram 1. (After IVERSEN—BJERNING—BING.) Scheme illustrating correlation between plasma concentration (counted in iodine) and tubular excretion of Diodrast. Below a plasma concentration of 5 mg % (so-called 'self-depression limit') the tubular excretion is proportional to the plasma concentration. When this limit is passed the excretion decreases in relation to the increasing plasma concentration. At a plasma concentration of 25 mg %, the tubular excretion has reached its maximum and keeps constant despite increasing plasma concentration.

In urography the plasma concentration of Umbradil is considerably above the threshold of 25 mg/100 ml iodine and most of the contrast medium will therefore be filtered through the glomeruli. Urography is thus more an evaluation of glomerular filtration than of tubular excretion. The principal difference between the clearance determinations and excretion of Umbradil in urography is schematically illustrated in Diagram 2; at the low plasma concentration used in clearance, only a small part is filtered through glomeruli; at the high plasma concentration in urography, the main part. Another difference is the need to have diuresis in clearance tests and a low rate of excretion in urography. Diuresis produces low concentration, and a low rate of excretion a high concentration of the contrast medium in the urine.

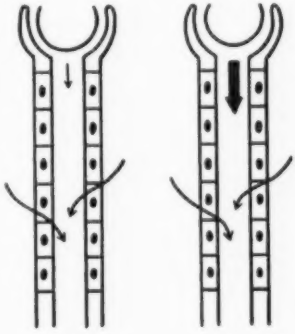


Diagram 2. Scheme illustrating the excretion of iodine compounds (Diodrast, Umbradil) at low (clearance), and high (urography) plasma concentration.

Method. In order to study a urologic material from the Surgical Department from another point of view one of us (C. A. E.)

performed determinations of inulin and PAH clearances of individual kidneys. (Will be published separately.)

The urine was collected by ureteral catheterization when both kidneys were intact, and from the bladder when a single kidney remained after nephrectomy. The clearance tests were performed according to a method elaborated by JOSEPHSON, BUCHT, EK and WERKÖ 1952. Inulin clearance was used as a measure of glomerular filtration and PAH-clearance as a measure of effective renal plasma flow. In order to obtain a full and better measurable renal effect the clearance determinations were performed during hydration of the patients, per os before, and intravenously during, the examination.

The clearance determinations of each kidney are compared with the appearances of the kidney in a urogram obtained in the Roentgen Department within the same week.

Material. The material consists of 19 in-patients with a total of 30 kidneys. It is divided into two main groups according to the findings on urography. Kidneys with high contrast density of the pelves form the first group (Table I) while kidneys with low contrast density of the pelves are collected into a second group (Table II).

To the first group belong 13 kidneys including one case (5) in which two-thirds of the pelvis showed a very high and one third a low density. Two further kidneys (3 right, 12 left) are border-line cases; the excretion

Table I

Kidneys with high contrast density of the pelves in urography

No. Case	Side	Diagnosis	C_{in} (max)	C_{PAH} (max)	Filtr. fract.	Urine ml/min	Remarks
1. 301127 ♀ ..	single	Normal	129	816	0.16	3.7	
2. 230930 ♀ ..	left	Normal	124	659	0.19	1.2	
3. 110822 ♀ ..	left	Normal	135	450	0.30	0.7	
4. 200630 ♂ ..	single	Normal	117	504	0.23	0.7	Upper two thirds high density, lower third low density
5. 100911 ♂ ..	"	Localized tuberculosis	120	401	0.31	2.1	
6. 010123 ♂ ..	"	Hydronephrosis	70	649	0.11	4.6	
7. 101314 ♀ ..	"	Nephrolithiasis	78	379	0.22	2.1	
8. 090612 ♂ ..	"	Coral calculus	71	384	0.25	3.0	
9. 170223 ♀ ..	right	Normal	59	287	0.21	2.2	
	left	Acute pyelonephritis	36	191	0.19	2.1	
10. 990127 ♀ ..	single	Localized tuberculosis	25	204	0.12	0.7	
11. 260801 ♀ ..	left	Pyelonephritis bil.	60	101	0.63	0.6	
	right		59	91	0.65	0.3	
12. 001104 ♀ ..	left	Pyelonephritis + Stat. post nephrolithiasis	32	188	0.17	2.6	Delayed excretion but high density
3. 110822 ♀ ..	right	Hydronephrosis	4	38	0.11	0.7	Delayed excretion but high density
Normal figures			46—73	200—355	0.18–0.28	> 0.5	

Table II

Kidneys with low contrast density of the pelves in urography

No. Case	Side	Diagnosis	C_{in} (max)	C_{PAH} (max)	Filtr. fract.	Urine ml/min	Remarks
13. 200212 ♂ ..	right	Pyelonephritis bil. (Papillitis necroticans)	96	287	0.33	1.2	
	left		67	200	0.34	1.6	
14. 200408 ♀ ..	right	Polycystic degeneration + Calculi	50	334	0.15	1.3	
2. 230930 ♀ ..	right	Pyelonephritis, Hypertension	17	165	0.10	0.2	
15. 220609 ♀ ..	left	Pyelonephritis bil., Hypertension	32	173	0.19	0.9	
	right		22	108	0.20	0.5	
16. 981108 ♀ ..	right	Pyelonephritis bil. (Papillitis necroticans)	26	114	0.23	0.6	
	left		22	98	0.22	0.6	
12. 001104 ♀ ..	right	Pyelonephritis + Nephrolithiasis	27	41	0.66	1.9	Very low density
17. 100408 ♀ ..	right	Pyelonephritis bil. (Papillitis necroticans)	19	64	0.30	1.0	Very low density
	left		19	59	0.31	1.1	Very low density
18. 070922 ♀ ..	left	Pyelonephritis bil., Hypertension	23	51	0.45	2.6	
	right		12	39	0.31	1.7	
14. 200408 ♀ ..	left	Polycystic degeneration + Calculi	8	57	0.14	0.8	
19. 150121 ♀ ..	single	Polycystic degeneration	12	29	0.41	3.9	Very low density
Normal figures			46—73	200—355	0.18–0.28	> 0.5	

was delayed but after 35 and 90 minutes, respectively, there was very good contrast filling of dilated pelves; they are also discussed in this group.

The remaining 15 kidneys, including one case (14 right) in which the upper-most part of the pelvis showed a fairly good contrast density after 90 minutes, are placed in the second group.

Results and discussion. In the first group the clearance tests indicated hyperfunction in 6 cases. Four (4) of them (1, 4, 5, 6) had single kidneys following nephrectomy, the remaining 2 (2, 3) having a contra-lateral kidney with low clearances indicating impaired function. The hyperfunctioning kidneys had inulin and PAH-clearances reaching twice the normal values for one kidney, revealing that such kidneys when working at full capacity are able to perform the function of two. The hyperfunction must be regarded as compensatory. The density of the pelves of these kidneys on urography does not differ from the normal (cf. left kidneys in Figs. 1 and 2 with right kidney in Fig. 3).

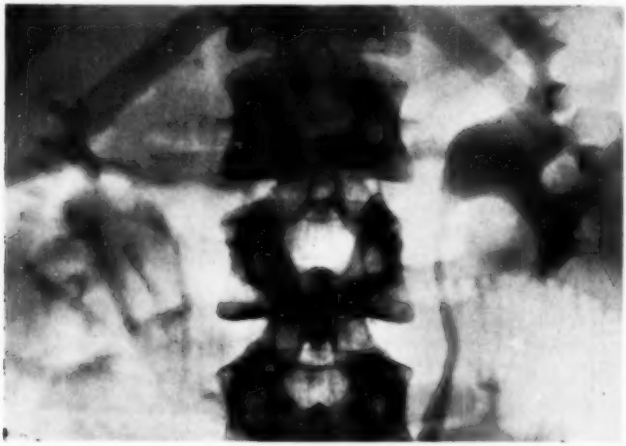
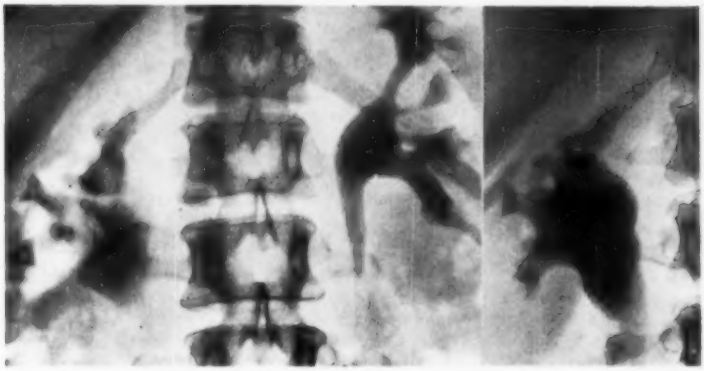


Fig. 1. Case 2. Urography, 17 min after injection of c. m. Right kidney: double pelvis; delayed excretion in upper pelvis with very low density, moderately lowered density in lower pelvis. Left kidney: excretion with high density. Clearances — right: $C_{in}17$, $C_{PAH}165$; left: $C_{in}124$, $C_{PAH}659$.

In the first group there were also three kidneys (7, 8, 9 right) which had clearances indicating normal function or a function at the upper level of normal values. Such single kidneys have not of course the same capacity as the hyperfunctioning kidney. On urography they showed a normal excretion of contrast medium (Fig. 3 a).

Six (6) kidneys (9 left, 10, 11 left and right, 12 left, 3 right) of clearances lower than normal, indicating reduced renal capacity, are also, however, found in the first group. In one of the kidneys, the PAH clearance was normal, in two others the inulin clearances were normal; local destructions of parenchyma or pyelonephritis were found in these cases.

In the second group of 15 kidneys with reduced contrast density of the pelves on urography, 12 had a corresponding reduction of glomerular filtration and plasma flow according to the clearances (cf. Fig. 5). From the point of view of degree of hypofunction, four kidneys with very low contrast concentration in the pelves are also those with the lowest clearances. The kidneys were damaged by pyelonephritis, necrotic papillitis, cystic degeneration, and coral stones. The remaining three kidneys (13 right and left, 14 right) had normal or better than normal clearances — indicating ordinary functional capacity despite the fact that they were not healthy. Two were pyelonephritic and the third had polycystic degeneration and calculi; the latter, however, showed fairly good contrast density of the upper part of the pelvis after 90 minutes.



a b

Fig. 2. Case 3. Urography, a) 44 min, b) 95 min after injection of c. m. Right kidney: delayed excretion with high density, dilated pelvis. Left kidney: excretion with high density. Clearances — right $C_{in}4$, $C_{PAH}38$; left: $C_{in}135$, $C_{PAH}450$. After several hours drainage of right pelvis normal clearances bilaterally.

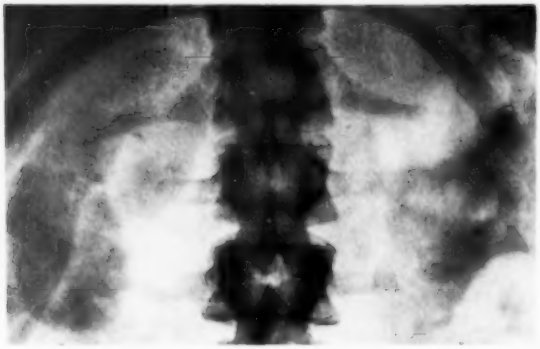
The material indicates that good contrast density of the pelves is not always a sign of normal capacity of the kidneys nor that poor contrast density of the pelves always means low renal capacity. The differences between the findings on urography and clearance determinations may in the main be explained by the nature of the two tests. The former is a qualitative, the latter a quantitative method. In addition, during urography the utmost effort is made to obtain the best conditions for morphologic studies of the pelves. The high plasma concentration of the contrast medium that is necessary causes a different mechanism of excretion than a low concentration, and one which corresponds more to the physiologic occurrence of foreign and toxic plasma constituents that the kidneys have to excrete.

Dehydration of the patient is included in the preparation for urography as a means of causing a low rate of excretion; this aids a high concentration of contrast medium in the pelves necessary for the morphologic study, but makes urography unsatisfactory as a functional test.

Diseases of extrarenal origin (diabetes, heart failure with retention of fluid, etc.) may cause diuresis and influence the urographic assessment, explaining a combination of low contrast density and normal clearances.

Ureteral compression facilitates contrast filling of the pelves and furthers a high concentration of the medium.

The excretion of contrast medium in urography gives no indication of the degree of renal function, that is, of the number of nephrons taking part in the process. Good filling of the pelvis in a compensatorily hyper-



a

b

Fig. 3. Case 9. Urography (+ shock). a. 18 min, b. 40 min after injection of c. m. Right kidney: first nephrographic effect, then excretion with high density. Left kidney: much less nephrographic effect than in right, then excretion with high density. Clearances — right: $C_{In}59$, $C_{PAH}287$; left: $C_{In}36$, $C_{PAH}191$.

functioning kidney produces as dense a shadow as in a dysplastic kidney with its fewer nephrons — with due consideration to the different size of the pelves. Nor does normal urography tell us the reserve capacity of a single kidney. In impaired kidneys urography affords no indication of the amount of functioning parenchyma which remains. When the pathologic changes are localized, urine of high contrast concentration from the intact parenchyma may flow into the damaged areas and mask their low contrast excretion. On the other hand, morphologic changes are much easier to diagnose (Olsson 1943).

As excretion in urography in the first instance is due to glomerular filtration, it depends mainly upon the arterial blood and intrapelvic pressures. Due to these facts, a decrease in blood pressure (shock) during urography (Wickbom 1950) and increased intrapelvic pressure in hydronephrosis or acute stasis, directly influence the excretion (Edling, Helander and Renck 1954).

One of the patients (9) in this material exhibited signs of shock and the findings are of interest. At a first urography one month previously during an attack of left-sided acute pyelonephritis, there was hardly any contrast excretion from the diseased kidney. At the second urography when signs of shock were apparent, a bilateral nephrographic effect obviously less on the left than the right side, was noted. When the shock

Fig. 4. Case 11. Urography, 29 min after injection of c. m. Both kidneys: excretion with high density. Clearances — right: $C_{in}59$, $C_{PAH}91$; left: $C_{in}60$, $C_{PAH}101$.

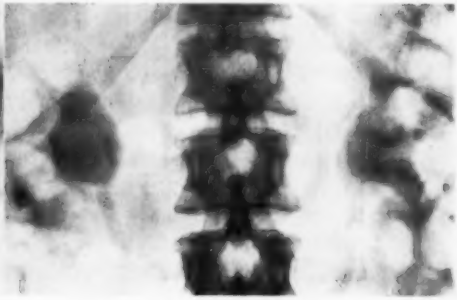


Fig. 5. Case 18. Urography, 32 min after injection of c. m. Both kidneys: excretion with low density. Clearances — right: $C_{in}12$, $C_{PAH}39$; left: $C_{in}23$, $C_{PAH}51$.

had passed off, excretion commenced in both kidneys and there was no difference in the contrast density of the pelves (Fig. 3). In the left kidney the clearances were low, in the right kidney normal. In this case the difference in nephrographic effect, contrary to the contrast excretion, corresponded to the differences in clearances. Due to fall in blood pressure the filtration pressure in the glomeruli was reduced. The glomerular filtration ceased. As the nephrographic effect was low in the kidney with lowered PAH clearance it may be reasonable to presume that the finding was caused by reduced tubular function. This case seems to support the opinion that the nephrographic effect depends in the main on the function of the tubular cells (Edling, Helander and Renck 1954). In addition it may indicate that the degree of nephrographic effect in a kidney is a more sensitive qualitative test of function than the degree of contrast density in the pelves. Further observation of such cases are necessary for definite conclusions.

In obstructions of the urine flow in anomalies, strictures, and stones, the intrapelvic pressure is increased and causes reduced glomerular filtration. However, the concentration of the filtrate may be unchanged or increased because the increased intrapelvic pressure furthers the reabsorption of water. These factors may contribute to a high concentration of the contrast medium in the pelvis. On the other hand, the fluid retained in the dilated pelvis dilutes the contrast medium excreted and postpones full density. The kidney must be studied for a sufficiently long period or the much delayed excretion may lead to it being labelled as non-functioning. In addition, a single urogram does not tell us if a low excretion is a sign of but temporary or of irreparable reduction of renal function. The difficulty in assessing such cases may be demon-

strated by one of the kidneys with hydronephrosis (3 right). There was a delayed but highly concentrated excretion of the medium into the dilated pelvis despite very low clearances (cf. Fig. 2). The contralateral kidney was compensatorily hypertrophied. The clearance examination proceeded with several hours drainage of the hydronephrotic kidney through a ureteral catheter, following which continuous determinations showed figures approaching normal in the drained kidney while the high clearances values of the hypertrophied kidney also decreased to normal levels.

Of special interest for the urographic examination are kidneys with a filtration fraction higher than normal. In 5 of the kidneys in the material the filtration fraction was more than 0.40 and without doubt much increased. Urographically 2 (11 right and left) had a high contrast density, 1 (18 left) a low contrast density, and 2 (12 right, 19) a very low contrast density of the pelves.

In such cases, more than the usual one-fifth of the effective plasma flow is filtered and consequently comparatively more contrast medium is passed via the glomeruli. Due to this and the urographic technic with dehydration of the patient and ureteral compression, the renal function judged by the urogram appears better than really exists. An explanation is thus afforded of the case (Fig. 4) in which the functional capacity of both kidneys was moderately lowered but yet showed a normal excretion of contrast medium. In the three other kidneys the functional capacity was too low for any excretion of high concentration.

The urographic method with dehydration and ureteral compression is specially directed at visualization of morphologic changes of the kidneys and is in this respect of the utmost importance; furthermore, it has rendered retrograde pyelography superfluous, except in a few selected cases. Urography may also be used as a means of an approximative qualitative evaluation of renal function. It cannot however be used as a sensitive meter of renal function as many factors influence the examination. It must always be combined with quantitative functional tests of the individual kidney when an exact measure of renal function is demanded.

SUMMARY

The authors discuss urography and selective clearances as tests of renal function. Urography to a certain degree affords a qualitative indication of renal function. When an exact measure of renal function is necessary, urography cannot replace quantitative tests upon the individual kidney.

ZUSAMMENFASSUNG

Die Verfasser diskutieren die Urographie und die selektiven Clearanceuntersuchungen als Mittel zur Prüfung der Nierenfunktion. Die Urographie gibt bis zu einem ge-

wissen Grade eine qualitative Auskunft über die Nierenfunktion. In Fällen, wo eine genaue Messung der Nierenfunktion notwendig ist, kann die Urographie quantitative Proben der individuellen Niere nicht ersetzen.

RÉSUMÉ

Les auteurs font une étude critique de l'urographie et des clearances sélectives employées comme tests de la fonction rénale. L'urographie donne dans une certaine mesure une indication qualitative sur la fonction rénale. Quand une mesure exacte de la fonction rénale est nécessaire, l'urographie ne peut remplacer les tests quantitatifs.

BIBLIOGRAPHY

Edling, N. P. G., Helander, C. G. and Renck, L.: The correlation between contrast excretion and arterial and intrapelvic pressures in urography. Acta radiol. 42 (1954), 442.

Iversen, P., Bjerning, T. and Bing, J.: De medicinske nyrelidelser. (Danish.) Ejnar Munksgaard, Köbenhavn 1946.

Josephson, B., Bucht, H., Ek, J. and Werkö, L.: Renal excretion, its depression, and the tubular storage of p-aminohippuric acid (PAH) in the healthy and in the diseased human kidney. Scandinav. J. Clin. Lab. Investigation 4 (1952), 1.

Josephson, B.: The mechanism of the excretion of renal contrast substances. Acta radiol. 38 (1952), 299.

Olsson, O.: Die Urographie bei der Nierentuberkulose. Acta radiol. Suppl. 47 (1943).

Smith, H. W., Goldring, W. and Chasis, H.: The mechanism of the tubular excretory mass, effective blood flow and filtration rate in the normal human kidney. J. Clin. Investigation 17 (1938), 263.

Smith, H. W.: The Kidney. Oxford University Press, New York 1951.

Wickbom, I.: The influence of the blood pressure in urographic examination. Acta radiol. 34 (1950), 1.

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TECHNIQUE FOR THE PHARMACO-DYNAMIC INVESTIGATION OF CONTRAST MEDIA FOR CEREBRAL ANGIOGRAPHY

Effect on the blood-brain barrier in animal experiments

by

Tore Broman and *Olle Olsson*

In 1948 we introduced an experimental procedure for investigating the tolerance of the cerebral blood vessels to contrast media, one which included the technique applied in the study of the blood-brain barrier. Since then this procedure has been widely used, and our results have been confirmed by several research workers who have made further contributions to this important aspect of cerebral angiography. We know that other investigations are in progress both in Europe and U. S. A. As the technical part of such an investigation requires meticulous care, we considered it might be useful to give a detailed account of the technique with special reference to the essential steps, especially regarding a factor that has hitherto received little attention, namely *the importance of the injection pressure.*

Experimental technique

Material. Rabbits anesthetised with 20 % Urethane injected intravenously.

Preparative operative measures. The free end of a glass cannula, the other end of which is in communication with a flask containing a small amount of saline, is introduced into one of the femoral veins. During the experiment proper this glass vessel serves as a container for the trypan blue solution.

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A tracheotomy tube is inserted to permit artificial respiration in the event of respiratory distress during the experiment. Both jugular veins are ligated in the lower neck as close as possible to the thorax and clamped cranially. Each vein is incised between the ligation and the clamp to permit the escape of contrast medium during the injection. The amount of medium used might otherwise exert a generalized toxic effect on the animal.

The skull is trephined on one side and the surface of the brain with the dura intact exposed in order to control visually that the injection pressure is sufficient to expel all the blood. Unless this expulsion is complete, the contrast medium will be diluted with blood and the concentration being tested will be decreased to an unknown degree. The carotid artery on the trephined side is dissected free, ligated near the thorax, and cautiously clamped cranially.

The injection needle is then inserted between the ligature and the clamp in a cranial direction into the carotid artery. The needle is connected to one limb of a T-tube by means of rubber tubing, the other limb being connected to a mercury manometer for the registration of the injection pressure. A syringe containing normal saline is connected to the same T-tube, which together with the rubber tubing and the injection needle is, of course, carefully filled with normal saline.

Pilot injection. The purpose of this pilot injection is to check the site of the needle, the injection pressure, and expulsion of blood, before the injection of the contrast medium. The clamp occluding the carotid artery cranial to the ligature is removed and saline injected, during which injection the pressure is noted and the brain surface inspected. The carotid artery is then again clamped. During the injection the blood in the pia vessels should be completely expelled by the saline under a pressure, at the most, of 200 mm Hg. As the manometer is connected to the syringe by a T-tube before the arterial injection needle, the intravascular injection pressure is, of course, slightly lower than that recorded by the manometer.

Injection of the contrast medium. The syringe containing saline and connected to the T-tube is now replaced by one containing contrast medium at body temperature. The clamps occluding the jugular veins are then removed to permit a free escape of the cranial venous blood. After the clamp on the carotid artery has been released, the contrast medium is injected under sufficient pressure to expel the blood from the vessels in the pia and the brain surface, a note being made of the duration of the injection in seconds.

Immediately after the end of the injection the carotid artery is again clamped and the needle withdrawn. The jugular veins are also clamped again to prevent further loss of blood. Trypan blue (0.5 per cent in saline

and freshly filtered) is infused intravenously. In the event of respiratory distress, artificial respiration is started.

Final stage of the experiment. After the animal has received about 100 ml of the trypan blue solution, the infusion is stopped. About 10 minutes after the beginning of the infusion of the dye the animal is bled by division of the thorax and excision of the apex of the heart. The clamps are removed from the jugular veins to facilitate the flow from the cerebral vessels. The left lung is removed and a glass cannula inserted into the aorta with the tip of the needle in a cranial direction. This cannula is connected by means of rubber tubing to a flask about 1 m above the animal and containing 200 ml of saline. The vessels are perfused with this solution to wash out the blue-coloured blood. For fixing the brain *in situ* formalin 10 % is later poured into the flask and the perfusion is continued, care being taken to prevent the entry of any air.

The fixed brain is now removed and inspected with the naked eye. If the cerebral blood vessels have been injured, the damage will be seen as a more or less distinct blueness of the brain on the side that received the injection (if the injection pressure was high and expelled the blood from regions other than those of the carotid artery, part of the other half of the brain may also be coloured). A predominantly unilateral lesion of the brain is in itself a sign that the injection pressure was essentially the same as the blood pressure.

Sources of error. All solutions to be injected into the carotid artery must be freshly filtered, in addition to which they should occasionally be inspected in transmitted light for the presence of impurities (microaggregates) capable of leading to micro-embolism. For instance, a simple defect such as a small hole in the filter is sufficient to spoil the experiments.

All needles, cannulae, tubes, and syringes, to be used for injection into the carotid artery should first be carefully filled with normal saline or contrast medium and examined for the presence of air bubbles. After the injection needle has been introduced into the artery, saline should be injected to remove any air bubbles or blood clots before ligation of the vessel to hold the needle in position. It is advisable to examine the artery between the ligature and the clamp in order to be sure that no small clot has adhered to the vessel wall after the arrest of the circulation. In the event of such clot formation, the vessel should be thoroughly rinsed before the injection needle is tied in position. As to the syringe containing the contrast medium, it should be observed that if it be allowed to stand for a while before use, precipitation is liable to occur at the tip of the needle where the contrast medium is exposed to the air. The medium should be warmed up to body temperature before injection.

If artificial respiration is necessary, the insufflation pressure should be carefully controlled to prevent undue distension of the lung tissue. If the insufflation pressure is too high, even though only momentary, ruptures may occur with consequent air embolism and massive cerebral injury.

Injury to the dura in connection with the trephining is liable to result in cerebral herniation and stasis of the blood in the vessels in the trephined region. The examiner may then have the impression that ordinary pressure is insufficient to expel the blood out of the cerebral vessels and apply too high an injection pressure. As this damages the vessels (see below), it involves the risk of erroneous evaluation of the results. Another possibility that may make it difficult to judge the injection pressure is that the carotid artery may be twisted against the underlying soft parts of the neck or pressed by the needle so that a considerable increase in the pressure is necessary to expel the blood from the cerebral vessels. In such cases the injection pressure recording is liable to be fictitiously high, or it may even not be possible to obtain a good filling of the cerebral vessels.

Significance of the injection pressure in the occurrence of toxic injury to the cerebral vessels by Umbradil

Results. We focused attention on this problem and carried out experiments with Umbradil 35 % which had been found to produce but slight injury in earlier investigations. The results are summarised in tabular form below.

Rôle played by the injection pressure as a causal factor of injury of the cerebral vessels in experimental angiography

No.	Solution	Dose	Time	Pressure	Impairment of permeability
1	Saline	100 ml	43 secs	>500 mm Hg	—
2	Trp. b.	50 »	20 »	320 » »	—
3	U. 35 %	30 »	25 »	140 » »	—
4	» »	30 »	20 »	160(—240) » »	—
5	» »	45 »	22 »	120 —180 » »	—
6	» »	23 »	10 »	200(—320) » »	?
7	» »	50 »	27 »	200 —240 » »	+
8	» »	48 »	22 »	250 —280 » »	++
9	» »	48 »	25 »	260 —320 » »	++
10	» »	28 »	7 »	>450 » »	+

The experiments showed that a high injection pressure *per se* does not produce any damage to the cerebral vessels. When, however, the saline solution was replaced by Umbradil 35 %, the vessels showed

evidence of damage as soon as the injection pressure exceeded 200 to 250 mm Hg. When injected under a pressure below this limit, however, the contrast medium produced no damage. Two factors, each harmless in itself, may in combination be injurious. Thus, the high pressure *per se* is not injurious. With the application time employed, Umbradil produced no injury to the cerebral vessels. The cumulative effect of these two factors, however, proved injurious. This is a further example of the cumulative effect described by BROMAN, FORSSMAN & OLLE OLSSON (1950). In clinical cerebral angiography, however, the injection pressure is presumably of minor importance, the tip of the needle being passed only a short distance into the artery, which is thus not occluded, so that in the event of high injection pressure, the blood can escape in a retrograde direction. The possibility of arterial hypertension being a contributory causal factor in lesions occurring during cerebral angiography cannot, however, be excluded.

SUMMARY

An account is given of the experimental technique for the pharmaco-dynamic investigation of the effect of contrast media on the blood-brain barrier. In combination with the effect of the contrast medium, the injection pressure proved to play an important rôle in the development of injury to the cerebral vessels. The maximum non-injurious injection pressure was found to be about 200 mm Hg.

ZUSAMMENFASSUNG

Ein Bericht über die experimentelle Technik für pharmakodynamische Untersuchungen über die Wirkung von Kontrastmitteln auf die Blut-Hirnbarriäre wird abgegeben. Zusammen mit dem Effekt des Kontrastmittels spielt der Injektionsdruck bei der Entstehung von Schäden an den Hirngefässen eine wichtige Rolle. Der maximale noch unschädliche Injektionsdruck beträgt etwa 200 mm Hg.

RÉSUMÉ

Les auteurs décrivent la technique expérimentale de l'étude pharmacodynamique de l'effet des moyens de contraste sur la barrière vasculo-cérébrale. Associée à l'effet des produits de contraste, la pression d'injection s'est montrée un facteur important dans l'apparition de lésions des vaisseaux cérébraux. La pression d'injection maxima inoffensive a été estimée à environ 200 mm Hg.

REFERENCES

BROMAN, T. & OLSSON, OLLE: The tolerance of cerebral blood vessels to a contrast medium of the diodrast group. Acta radiol. 30 (1948), 326.

— Experimental study of contrast media for cerebral angiography with reference to possible injurious effects on the cerebral blood vessels. Acta radiol. 31 (1949), 321.

BROMAN, T., FORSSMAN, B. & OLSSON, OLLE: Further experimental investigations of injuries from contrast media in cerebral angiography. Acta radiol. 34 (1950), 135.

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SOME EXPERIENCES WITH TOMOGRAPHY IN NEURORADIOLOGY

by

Vincenzo Valentino

Tomography may prove to be a valuable method of examination when a more exact assessment of the anatomic conditions in certain neuroradiologic cases is required. There is no doubt that some structures of the base of the skull are better studied by means of tomography than by the conventional roentgenographic method alone. LINDGREN in his recently published textbook of neuroradiology, states: "Bei Einzeluntersuchungen bestimmter Skeletteile kann in gewissen Fällen die Tomographie wertvolle Aufschlüsse geben. Dieses gilt weniger bei Veränderungen in der Kalotte, wo die Tomographie nach Ansicht der Verfasser keine weiteren Aufklärungen gibt, sondern hauptsächlich bei Veränderungen in der Schädelbasis, z. B. Zerstörungen im Clivus. Destruktionen in den hinteren Teilen der Orbits können in gewissen Fällen bei der Tomographie deutlicher zu sehen sein als bei gewöhnlicher Untersuchung, und Veränderungen in der Gegend der Incisura infraorbitalis sind schwerer festzustellen, wenn die Tomographie nicht angewandt wird." Our experience is in agreement with this statement. In certain schools there is a tendency to over-employ the tomographic method in the neuroradiologic field. We have the impression that often, too often, some roentgenologists utilize this technique at the expense of the conventional method which, if properly used, could have given the same results. Tomography has to be used in well-determined cases. In order to prove the importance of the tomographic method, it is, in our opinion, necessary to compare the results with those obtained with the conventional technique. Only if the tomographic method is capable of offering us more information than a 'properly and correctly used conventional tech-

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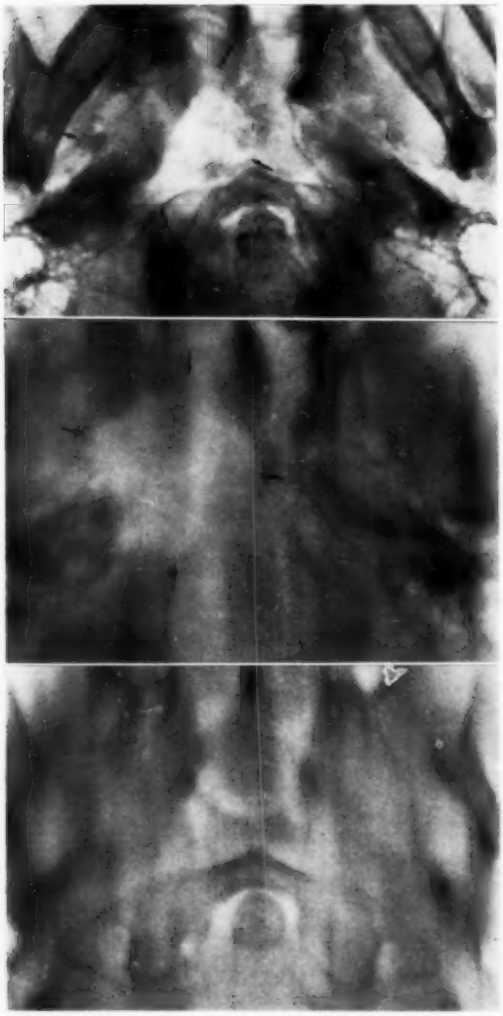

Fig. 1. Case 1. Meningioma of the posterior aspect of the petrous bone (verified). a. Conventional roentgenogram of the base of the skull. Bone destruction (arrows). b and c. Tomograms. The layer close to the inside of the cranial cavity shows (b) the bone destruction (arrows); no definite changes in the layer taken through a plane nearer the nasopharynx (c). The site of the tumour in the cranial cavity may be considered proved.

nique', may the superiority of the former method be considered proved in that particular case.

Bone destruction of the base of the skull in the region of the middle fossa is often well demonstrated in conventional roentgenograms. Tomography may, however, show the destruction more clearly and also give information about the site of origin of the bone-destroying process.

Case 1. The conventional roentgenogram (Fig. 1 a) shows the destruction of the base of the skull in the region of the middle fossa fairly well. However, it seemed difficult to decide whether the process had originated in the cranial cavity or outside the skull (*i. e.* tumour of the nasopharynx). Tomography showed the destruction much more clearly, and, furthermore, that it had arisen inside the skull: tomograms taken in different planes (some close to the cranial cavity, others nearer the nasopharynx) revealed that the destruction diminished towards the outside of the skull (Fig. 1 b and c). This observation made it possible to rule out a tumour of the nasopharynx. At operation, a meningioma of the posterior aspect of the petrous bone, with its main extension into the middle fossa, was found.

Bone changes in the region of the sphenoidal plane, in cases of meningioma of this region, may generally be shown in the conventional roentgenograms. To-

a b c

Fig. 2. Case 2. Normal case. a. Roentgenogram. Thickening in the pterional region, which could have lead to the diagnosis of pterional meningioma. b and c. Tomograms through the pterional regions, (b) the right side, and, (c) the left side. The thickening is symmetric. A pterional meningioma may therefore be ruled out.

a b

Fig. 3. Encephalography *ad modum* LINDGREN. a. Conventional roentgenogram (no clear visualization of the posterior part of the ventricular system). b. Tomogram in the same case.

Fig. 4. Position of the patient for encephalography and supplementary tomography.

mography, however, may define the bone change more clearly and provide evidence as to the anatomic site of the anterior part of the planum ethmoidosphenoidale. Meningiomas arising from the tuberculum sellae, and those with their origin in the olfactory groove, produce very similar changes in the region of the sphenoidal plane. Olfactory groove meningiomas, however, in addition cause bone erosion of the anterior part of the planum ethmoidosphenoidale, an erosion which is not found in cases of meningiomas arising from the tuberculum sellae. The difficulty of showing the anterior part of the planum ethmoidosphenoidale in conventional roentgenograms is well known. "Die Lamina cribosa wahrzunehmen kann indessen auch im Normalfall oft schwer sein und die Tomographie dann als Ergänzung der gewöhnlichen Untersuchungen von grossem Wert sein", as LINDGREN writes in 'Handbuch der Neurochirurgie'.

In *Case 2*, the lateral conventional view of the skull shows a projection of increased bone density in the region of the pterion (Fig. 2 a). Tomography disclosed an anatomic anomaly in the form of an area of increased bone density, symmetrically situated in the two pterional areas.

Concerning the use of tomography, when encephalographic examinations are employed, LINDGREN may again be quoted: "Besonders in der französischen und italienischen Literatur kann man den Eindruck erhalten, dass die Tomographie von grossem Wert sein würde. Nach den Erfahrungen des Verfassers ist das nicht der Fall, bei Untersuchungen

von der Art und mit der Technik, wie vom Verfasser gearbeitet wird und an der Röntgenabteilung des Serafimerlasarettet angewandt wird." We agree in principle with this opinion. It seems to us, however, that in certain cases the first roentgenogram of an encephalographic examination, carried out *ad modum* LINDGREN, may with advantage be complemented with a tomogram, where the fourth ventricle and the aqueduct are visualized free of the petrous bones. At this stage it seems clear that tomography leads to better results, with only slightly increased technical inconveniences in comparison with conventional radiography.

As routine examination, we carry out encephalography in conformity with the procedure described by LINDGREN. If the first film shows the posterior part of the ventricular system fairly well, tomography is not employed. On the other hand, if this first film does not define the region properly (Fig. 3 a), we keep the patient in the same position (Fig. 4) and take a tomogram (Fig. 3 b).

SUMMARY

The value of tomography in the neuroradiologic field, based upon two illustrative cases, is discussed.

ZUSAMMENFASSUNG

Die Bedeutung der Tomographie auf dem Gebiete der Neuroradiologie wird unter Zugrundelegung zweier illustrativer Fälle diskutiert.

RÉSUMÉ

Se basant sur deux cas pris comme exemples, l'auteur examine l'intérêt de la tomographie en neuroradiologie.

REFERENCES

DI CHIRO, G., and LINDGREN, E.: Bone changes in cases of suprasellar meningioma. Acta radiol. 38 (1952), 133.

LINDGREN, E.: *In* Handbuch der Neurochirurgie. Bd. II. Röntgenologie. Hrsgb. von OLIVECRONA und TÖNNIS. Springer Verlag, Berlin 1954.

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PLACENTA PRAEVIA

by

Ragnar Hol

Many methods have been applied to determine the site of the placenta. Among these *amniography* and *placentography* with thorium and other contrast media are now probably of mere historical interest. (*Tomography* has been little used for this purpose.)

This paper will deal with soft tissue roentgenography as the principal method, the deviation method and cystography being supplementary to the former.

Arteriography of the placenta gives an exact determination of the placental site (HARTNETT, NORMAN and others). When an exact diagnosis can be achieved by conventional roentgenography this may be the best method as it can be carried out anywhere. There will always remain some uncertain cases in which arteriography will be superior.

A. Soft tissue radiography

In 1934 SNOW and POWELL described the normal placenta as seen in soft tissue roentgenograms. Since then this technique has been much used, with or without the use of filters to ensure uniform exposure of all parts of the film (DIPPEL and BROWN, BAYLIN and LAMBETH, BISHOP, REID, SOHRNE and QUIST, among many others).

According to REID, the placenta should be 20 to 25 cm long, but may be a little more or less; it should not usually be diagnosed as such unless it is 4 cm thick in its central part.

Unfortunately it is impossible to differentiate between the uterine wall and liquor amnii, and the placenta, in the roentgenograms. One can only observe the varying thickness of the 'uterine wall' delineated on the one side by the outer uterine border and on the other by the

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Fig. 1. Soft tissue structure of placenta situated posteriorly in fundus. Left lateral recumbency.

Fig. 2. Soft tissue film of twins with one placenta situated low anteriorly (placenta caesaria).

fetal parts, *viz.* the fetal panniculus (Figs. 1 and 2). The observations are usually made on a film of the abdomen in the lateral view. The following sources of misinterpretation have to be considered.

1. Failure in finding a placenta which really is situated in the upper uterine segment may be due to lateral obliquity of the uterus, asymmetry of the placental site, placenta membranacea extending over a greater area of the uterine wall, and multiple pregnancy with much overlapping of fetal parts. Oblique projections may be of value.

2. The erroneous diagnosis of a placenta in the upper segment (and the overlooking of a low site) may be made in excess of liquor amnii, accidental haemorrhage, placenta bipartita, or twins with two placentas, one of which covers the internal os.

3. A soft tissue mass extending to the lesser pelvis may also be a pelvic tumour, a uterine fibroma, or, though seldom, the non-pregnant part of a uterus duplex. As mentioned under 2, excess of liquor amnii or accidental haemorrhage may also be misleading.

The original premise put forward by SNOW and POWELL was that observations made on lateral films of the abdomen could indicate or exclude a placenta praevia. Later on attention was drawn to the bony

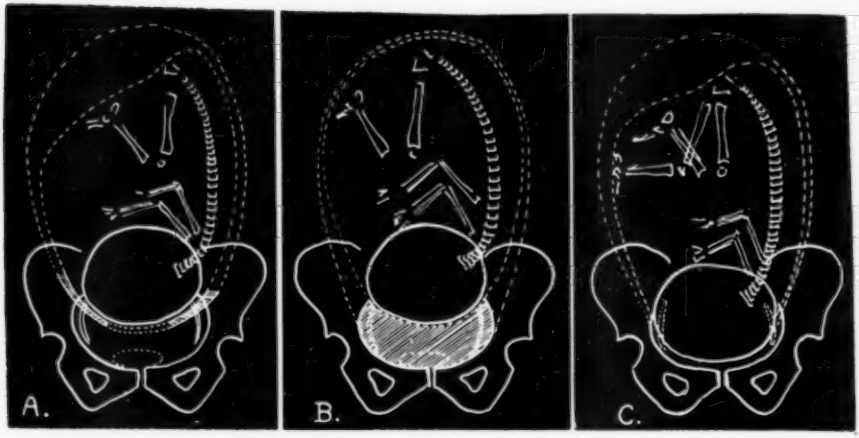

Fig. 3. Schematic drawing of pelvic soft tissue structures. A — head lying high, placenta in fundus. B — head lying high, complete placenta praevia. C — head about to engage, placenta in fundus.

as well as the soft tissue structures in the lesser pelvis. Frontal and lateral views of the pelvis in which the bony structures are just visible may give much valuable information.

In frontal films of the pelvis a narrow more translucent zone is shown parallel to the lateral walls of the lesser pelvis. This is due to a fatty layer situated between the soft parts of the pelvic wall and the intrapelvic organs (FRIMANN-DAHL). In late pregnancy this clear zone is intersected by the lower anterolateral uterine border, which is just visible at this point. The lower border of the uterus separated from the bladder tissue by a fine translucent band may also be observed in the mid-line. These soft tissue structures are best seen when the fetal head lies high. In total *placenta praevia* and when the head is about to engage, these pelvic structures are more obscured (Fig. 3).

In lateral films of the pelvis, soft tissue structures are more easily studied in the anterior than in the lower and posterior regions. Behind the subcutaneous fat of the mother a fine structure corresponding to the distended abdominal muscles and muscle sheaths is discernible. A clearer zone due to preperitoneal fat delineates the outer uterine contour and this extends down into the retropubic tissue, *viz.* the bladder. In pregnant women the bladder and perivesical tissue are displaced more or less upwards, and even a 50 ml bladder content may make the summit of the bladder rise markedly above the pubic level (Fig. 4). This soft tissue mass is often wedge-shaped with its greatest breadth behind the os

pubis and diminishing upwards. It is usually seen separated from both the uterus and the abdominal muscles by a very thin translucent band.

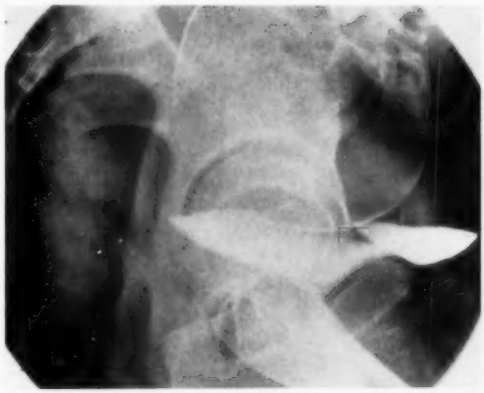

Fig. 4. Filling of bladder with 50 ml contrast medium makes the summit rise above level of pubes.

The uterine wall (possibly plus liquor amnii and the placenta) is usually clearly delineated. When the head is presenting the anterior soft tissue mass is triangular with its greatest breadth corresponding to the fetal neck where, more often than not, a small collection of liquor amnii is present. On this triangular part one may measure the breadth of the uterine wall at the upper and lower angles, the former exceeding the latter by some 1 to 2 cm. In a breech presentation this structure has a bandlike appearance and slightly increases in breadth upwards (Fig. 5).

Visualization of the uterine wall is more inconstant in the lower and the posterior part of the lesser pelvis. However, even very small amounts of gas or scybalae may disclose the uterine wall as a denser convex contour outlined by the contents of the bowel. Only when a larger part of the placenta is in a low posterior position may it definitely increase the density of the posterior region, and thus strongly suggest a placenta praevia (Fig. 6).

A centimetre rule should be placed between the thighs of the patient for measuring the uterine wall. Local increased breadth of the uterine wall does not necessarily indicate a low lying placenta unless it is continuous with a larger soft tissue mass near the pelvic inlet. The lower the placenta is situated, the more asymmetric will be the uterine wall. In total placenta praevia

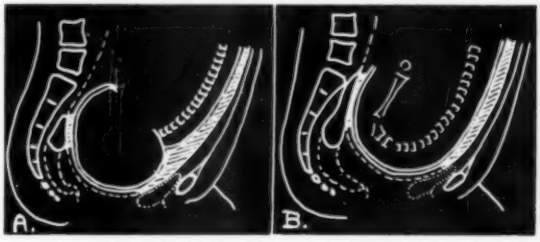

Fig. 5. Hatched areas are the parts of 'uterine wall' which may be made visible in lateral soft tissue roentgenograms of pelvis. A — head presentation. B — breech presentation.

Fig. 6. Placenta praevia (marginal posterior). Head displaced forward by soft tissue mass.

the soft tissue mass covers the whole pelvic inlet.

To summarise, one may say that all parts of the uterus should be examined by the soft tissue technique in lateral as well as in the frontal projections. The above-mentioned sources of diagnostic errors should be borne in mind.

Diagnostic considerations:

1. The elimination of a placenta praevia should be based on the finding of both a characteristic soft tissue mass in the corpus uteri and normal soft tissue structures in the pelvic region.

2. A placenta praevia should not be diagnosed with certainty unless marked local thickening of the intrapelvic uterine wall is observed consisting of, or in close connection with a large soft tissue mass.

Even in a breech presentation much valuable information may be gained by a close study of the soft tissue structures. The panniculus on the buttocks may often, like the head in a vertex presentation, define the inner uterine contour very well. It seems likely and may often be observed in the roentgenograms that the lower uterine segment has become moulded by the presenting part, usually leaving little space for the liquor amnii.

B. Displacement method

In 1941 GOLDEN and BALL stated that the fetal head should normally lie in the mid-coronal and mid-sagittal plane of the pelvic inlet, and that displacement from either, equivalent to a third or more of the diameter of the head, indicated a placenta praevia if the presenting part were entirely above the pelvic brim. The patients were examined in the erect position.

In 1944 MCCORT, DAVIDSON and WALTON found that the average distance from the fetal head to the sacral promontory in normal cases was 1.7 cm and the head—pubis distance was 3 cm. The measurements in placenta praevia were 3.4 and 4.9 cm respectively. Their cases were not examined in the erect position.

REID (1949) also used the bony pelvis in evaluating the thickness of the lower uterine segment and for this purpose he examined his patients

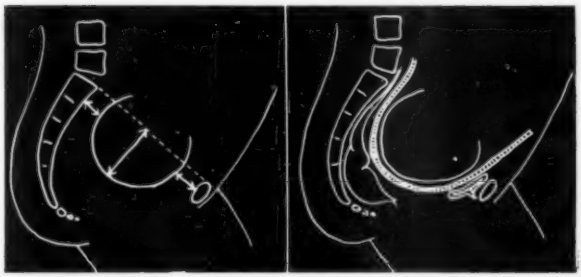

Fig. 7. *Left:* Measurements taken in normal cases: true conjugate, position of head (cm below pelvic inlet), anterior and posterior brim—head distances. *Right:* Schematic drawing of pelvic structures. From before backwards: pubis, bladder, uterine wall, liquor amnii, head, liquor amnii, uterine wall, rectum, sacral promontory.

standing. He stated that when the head—pubis or head—promontory distance measures 2 cm or more, low normal placenta cannot be excluded, but placenta praevia is more likely the more the presenting part is displaced either antero-posteriorly or laterally and the nearer the pregnancy is to term.

Values between 1.5 and 2 cm are not necessarily abnormal, but if the gap is continuous with a typical soft tissue structure on the upper segment it is probably due to the lower margin of the placenta. In the sixth and seventh month of pregnancy, when the upper segment may be partly intrapelvic, it indicates a normal but unusually low placenta. In the eighth and ninth month it may be due to implantation extending slightly onto the lower segment. A major degree of placenta praevia can be excluded.

Finally, when the gap head—pelvic brim is less than 1.5 cm, this space mostly indicates uterine muscle and when the separation is only 3 or 4 mm, more likely the lower segment. In some cases REID augments the film in the lateral projection with another taken semi-erect in order to exclude any apparent forward displacement from the sacral promontory caused by laxity of the abdominal wall (predominantly in multiparae). Semi-erect positioning of patients who cannot stand is also recommended.

Own investigations. STALLWORTHY mentions that examinations in the recumbent position may also be helpful. It has been my experience that much valuable information may be gained when the limitations of examinations in this position are known.

I have measured the head—promontory and head—pubis distances in lateral recumbency (Fig. 7) in 105 pregnancies in which a low lying

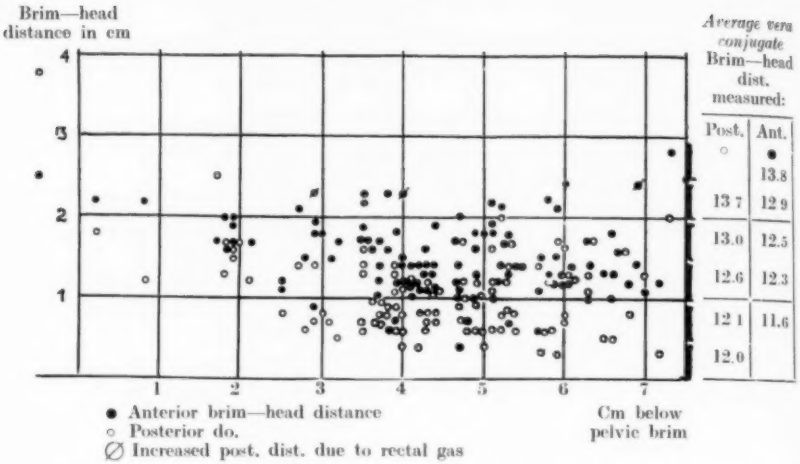

Diagram of measurements taken in 105 normal pregnancies, head presentations (35 to 40 weeks).

placenta could be excluded (no deeply situated soft tissue structure). The material consists of gravidae in the eighth and ninth months. The results are shown in the diagram and may be summarised as follows:

1. The measured values may be compared with the figures given by REID only when the head stands 2 cm or more below the pelvic brim. The examination is of less value when the head lies higher.

2. The head—promontory distance should not exceed 1.5 cm unless a certain amount of gas distends the rectum (Fig. 8, 3 cases).

3. The head—pubis distance should not exceed 2 cm.

4. When the pelvis is larger than the average, one may accept the limiting values 2 cm and 2.5 cm for the head—promontory and head—pubis distances respectively (Fig. 9).

5. The gap head—pubis is usually 0.5 to 1 cm larger than the head—promontory distance.

Comments. An examination in the erect position will tend to reduce the head—pelvic brim distance. This is due partly to a displacement of a small amount of liquor amnii in the lower segment and partly to the uterus and its contents descending with consequent compression of the pelvic tissues. The reduction of the head—pubis distance in the erect compared with the recumbent position is probably due chiefly to compression of the pelvic tissues, *viz.* the bladder, provided no major degree of hydramnion is present. (The instillation into the bladder of a small amount of contrast medium will, in the recumbent positions, often

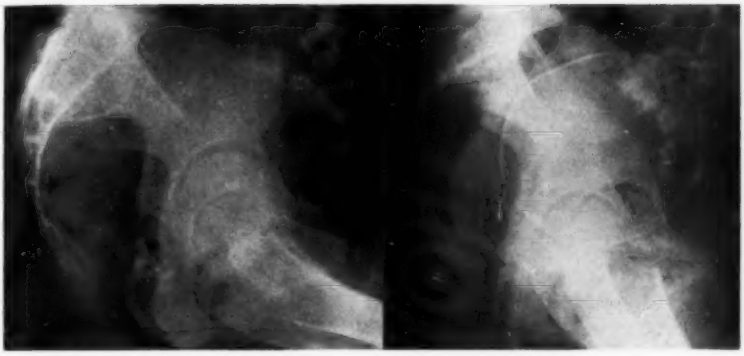

Fig. 8. Head displaced forward by the distended rectum (gas and scybalae).

Fig. 9. Large pelvis, no signs of placenta praevia. True conjugate 14.1 cm. Head—pubis and head—promontory distances 2.8 cm and 2 cm respectively.

give bladder—head distances comparable with the values given by REID for the head—pubis gap.

When the head reaches 2 cm or more below the pelvic inlet, the difference between the values in the lateral recumbent and erect positions is not significant as regards the head—promontory gap. In the lateral positioning of the patient, no major forces will affect the head—brim relationship and apparent forward displacement is less probable.

The most important objection against the examination in the lateral recumbent position, however, is that one will be unable to bring a head lying at a high level nearer the pelvic inlet. As mentioned previously the lower segment often appears fairly well adapted to the presenting part when the films are of moderate softness. Instead of measuring the head—brim distance one will then have the opportunity of measuring the breadth of the uterine wall. Only in a few uncertain cases should re-examination in the erect or semi-erect position be necessary. It has not been done in my present cases.

C. Cystography

Since this method was introduced by UDE, WEUM and URNER (1934) it has been employed by many authors. A contrast fluid, varying in amount from 40 ml to 250 ml, is instilled into the bladder. In a cephalic presentation, the bladder—head distance should not, according to UDE, WEUM and URNER, exceed 1 cm although opinions as to the limits of the normal vary from 6 to 8 mm up to the much higher maximum figure of 2.2 cm. In total placenta praevia, a considerable increase in the bladder—

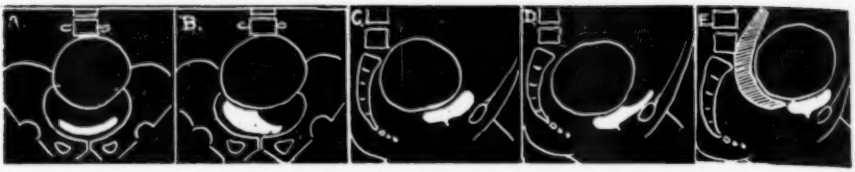

Fig. 10. Schematic drawing of cystography in pregnancy. Head presentation. A — Flattened bladder and increased bladder—head distance in placenta praevia. B — Unilateral deformation of bladder by soft tissue mass. C — Delineation of anterior uterine wall in normal case. D — Anterior deformation by low lying placenta. E — Posterior placenta praevia covers internal os. Bladder—head distance normal.

head distance is observed and, as described by FROSTAD, the bladder is flattened (Fig. 10, A).

When only a part of the placenta extends to and covers the internal os, diagnosis is difficult. BJERRE advises re-examination in the erect position in uncertain cases and found that the gap in normal cases was then reduced to less than 1 cm.

Cystography will *not*, however, disclose a placenta lying low posteriorly and covering the internal os but not extending forwards to the bladder (JARCHO) (Fig. 10, E). Simultaneous rectal insufflation has been recommended in order to rule out this possibility (LINDBLOM, SOHRNE, BORELL, FERNSTRÖM and WESTMAN).

Furthermore, cystography may be helpful in:

excluding any retention. In spite of catheterisation some urine may still remain in the bladder. Fifty (50) ml of contrast medium may be instilled before the catheter is withdrawn;

showing unilateral compression of the bladder by a soft tissue mass in the pelvic region (MCCORT, DAVIDSON and WALTON) (Fig. 10, B);

giving a better delineation of the lower anterior border of the uterine wall, especially below the pelvic inlet (Fig. 10, C, lateral view);

demonstrating anterior compression of the bladder by a low lying placenta in this region and in many cases better opportunity of determining its lower border (Fig. 10, D).

The above methods may often complement each other in giving a detailed picture of the anatomy of the pregnancy (MCCORT, DAVIDSON and WALTON). As in other medical examinations the combined information gained may be helpful when single observations are uncertain, and one single sign may on the other hand lead to a correct diagnosis.

Thus an abnormal shape of the pelvic inlet or even the non-distension of the lower abdominal muscles (REID) may suggest that a deviated head or one lying at a high level is not necessarily caused by a low lying placenta and that this should be sought for elsewhere.

The literature shows that there will always be some uncertain cases. In these arteriography with timed interval exposures may well prove decisive, although unfortunately its use is limited to the larger central clinics, while childbirth is widespread.

SUMMARY

The author discusses the value and limitations of the soft tissue and deviation methods as well as cystography in placenta praevia. The roentgen technique appearances, particularly in the soft tissue method, are described. It is pointed out that all the methods may be useful in presenting a complete and detailed picture of the condition present.

ZUSAMMENFASSUNG

Der Verfasser diskutiert den Wert und die Begrenzung der Weichteil- und Deviationsmethoden sowie der Zystographie bei der Placenta praevia. Die Röntgentechniken, besonders die der Weichteilmethode, werden beschrieben. Es wird hervorgehoben, dass alle Methoden zur Feststellung eines vollständigen und detailreichen Bildes dieses Zustandes wertvoll sein können.

RÉSUMÉ

L'auteur examine la valeur et les limites des méthodes de radiographie des parties molles et de la cystographie dans le diagnostic du placenta praevia. Il décrit les aspects techniques radiologiques, en particulier dans la méthode des parties molles. Il souligne que toutes les méthodes peuvent être utiles pour établir un tableau complet et détaillé de l'affection présente.

REFERENCES

Baylin, G. J. and Lambeth, S. S.: Roentgen diagnosis of placenta praevia. Radiology 40 (1943), 497.

Bishop, P. A.: Symposium on recent advances in gynecology and obstetrics; roentgen visualization of placenta. S. Clin. North America 25 (1945), 1994.

Bjerre, H.: On the roentgenological diagnosis of placenta praevia. Acta obst. et gynec. Scandinav. 20 (1940), 47.

Borell, U., Fernström, I. and Westman, A.: Indications for and the scope of indirect placentography in the diagnosis of placenta praevia. Acta obst. et gynec. Scandinav. 33 (1954), 231.

Dippel, A. L. and Brown, W. H.: The use and limitations of soft tissue roentgenography in placenta praevia and in certain other obstetrical conditions. Bull. Johns Hopkins Hosp. 66 (1940), 90.

Frimann-Dahl, J.: Roentgen examinations in acute abdominal diseases. Charles C. Thomas, Springfield, Ill. U. S. A. 1951.

Frostad, H.: Röntgenologisk undersökelse av placenta praevia. (Norwegian.) Nord. Med. 8 (1940), 2078.

Golden, R. and Ball, R. P.: Roentgenologic sign for detection of placenta praevia. Am. J. Obst. & Gynec. 42 (1941), 530.

Hartnett, L. J.: Possible significance of arterial visualization in diagnosis of placenta praevia; preliminary report. Am. J. Obst. & Gynec. 55 (1948), 940.

JARCHO, J.: Placenta praevia: roentgen diagnosis, treatment and technique for induction of premature labour. Am. J. Surg. 48 (1940), 485.
LINDBLOM, K.: Roentgenologic diagnosis of posterior wall placenta praevia. Acta obst. et gynec. Scandinav. 23 (1943), 344.
MCCORT, J. J., DAVIDSON, C. N. and WALTON, H. J.: Determination of the placental site in bleeding during the last trimester of pregnancy. Am. J. Roentgenol. 52 (1944), 128.
NORMAN, O.: Localization of the placenta by means of arteriography and auscultation (symposium). Brit. J. Radiol. 26 (1953), 393.
QUIST, C. F.: Soft tissue radiography of the placenta. Acta radiol. 37 (1952), 510.
REID, F.: Radiological localization of the placental site. Brit. J. Radiol. 22 (1949), 81, 551, 643.
SNOW, W. and POWELL, C. B.: Roentgen visualization of placenta. Am. J. Roentgenol. 31 (1934), 37.
SOHRNE, G.: Roentgenological diagnosis of placenta praevia. Acta radiol. 23 (1942), 541.
STALLWORTHY, J.: The dangerous placenta. Am. J. Obst. & Gynec. 61 (1951), 720.
UDE, W. H., WEUM, T. W. and URNER, J. A.: Roentgenologic diagnosis of placenta praevia. Am. J. Roentgenol. 31 (1934), 231.

FROM ROENTGEN DEPARTMENT I (DIRECTOR: DOCENT G. JÖNSSON), SÖDERSJUKHUSET, STOCKHOLM, SWEDEN

THORACIC AORTOGRAPHY BY MEANS OF A RADIOPAQUE POLYTHENE CATHETER INSERTED PERCUTANEOUSLY

by

Per Ödman

Thoracic aortography should be carried out according to the following principles:

1. The technique of the introduction of the contrast medium into the aorta should be as safe and simple as possible. Three alternative procedures have been described.

A. Direct puncture of some part of the thoracic aorta with a needle (NUVOLI, RADNER 1945, DEL CAMPO and HOYOS, EULER, WICKBOM, inter alios).

B. Insertion of a catheter into the thoracic aorta from a peripheral artery (RADNER 1948, BRODÉN et coll., HELMSWORTH et coll., RICKLIN, inter alios).

C. Retrograde injection of contrast medium from one of the branches of the thoracic aorta with a needle or a catheter (CASTELLANOS and PEREIRAS, STEPHENS, FREEMAN, BURFORD and CARSON, inter alios).

All of these procedures involve more or less great risks and will sometimes require fairly complicated arrangements. Several of the methods, including the one described by RADNER in 1948, are devised with special consideration to those cases in which the ascending aorta cannot be reached by catheterization through one of the branches of the abdominal aorta, *e. g.* in coarctation of the aorta or large aneurysms.

2. The injection of the contrast medium should be performed in such a way that it involves the least possible risk of damage by the toxicity of the solution. According to JÖNSSON et coll. "the contrast medium is least apt to cause a reaction when it is allowed to flow into the middle of the ascending aorta".

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3. The whole of the thoracic aorta with its main branches should be clearly visualized. This is obtained by the injection of a contrast solution of sufficient amount and concentration, and its deposition at a suitable site.

The method of thoracic aortography published by RADNER in 1948 and by BRODÉN et coll. will probably fulfil these requirements better than any other technique described up to the present. The procedure is as follows: A Cournand catheter is inserted into the arterial system and the tip then guided to the middle part of the ascending aorta under fluoroscopic control. In this position the contrast medium is injected by means of a kind of pressure apparatus. However, the catheter must be of a relatively large calibre (in examinations of adults, at least no. 8 F) so that the contrast medium can be introduced sufficiently rapidly. The insertion of a catheter of this size into the arterial system can only be carried out by the exposure and incision of a relatively large artery. In thoracic aortography by RADNER's method of 1948, one of the radial arteries is used for this purpose. After examination, the catheter having been removed, the vessel must be ligated (JÖNSSON et coll.). For this reason one is not inclined to repeat an examination of this kind, even though it might be clearly indicated. Catheterization of the ascending aorta from the left radial artery cannot be carried out in some instances, because of unfavourable anatomic and topographic conditions. In such patients only one artery is available, *viz.* the right radial artery. Hence, in these cases there is merely one possibility of performing thoracic aortography by RADNER's technique.

In using the methods of percutaneous insertion of a catheter (PEIRCE, LINDGREN, SELDINGER, and others) these difficulties are avoided. The time-consuming exposure of the artery will be unnecessary and no vessel need be sacrificed.

The essential principle of these methods is that relatively small-sized polythene catheters are inserted percutaneously into the arterial system. These types of catheters have a much thinner wall than the Cournand catheters. Through such polythene tubing inserted percutaneously to the aorta the contrast medium can be injected at a rate which is sufficiently great to enable distinct visualization of the aorta (LINDGREN, SELDINGER).

However, the polythene tubing available in the market is of such low radiopacity that it cannot be seen on screening. It is therefore difficult to determine its position in the arterial system. To compensate the low radiopacity of this type of catheter the following measures are recommended. A metal guide, obvious on fluoroscopy, may be inserted into the polythene tubing (LINDGREN, SELDINGER), or during the injection of contrast medium a film may be obtained of the area in which

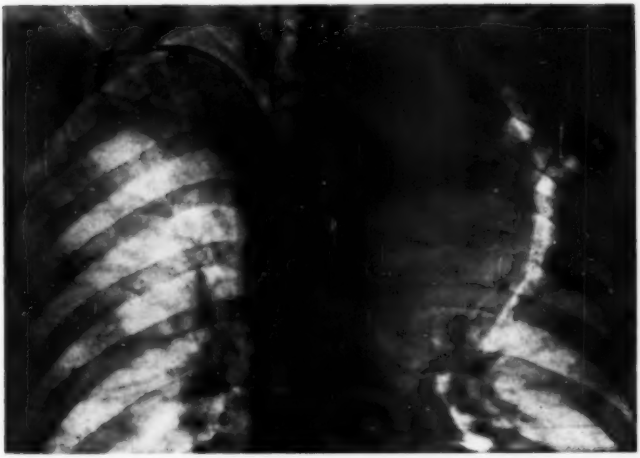


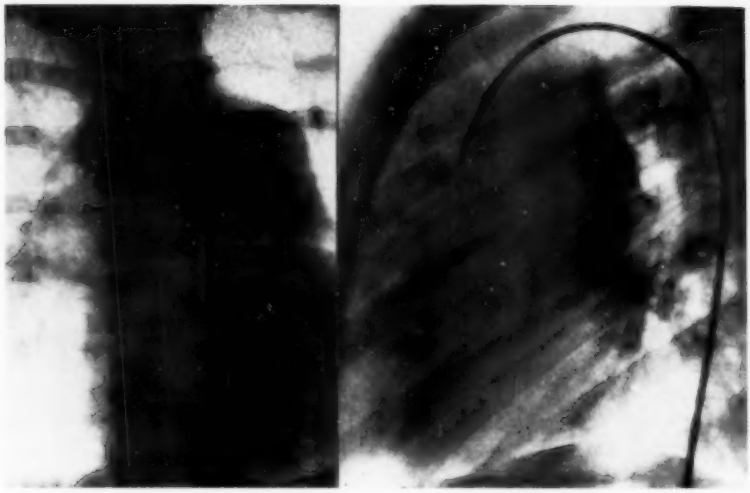
Fig. 1. Large aneurysm involving the aortic arch and the upper part of the ascending aorta. A radiopaque polythene catheter inserted percutaneously through the right brachial artery into the arterial system. The tip lies at the centre of the aneurysm.

the tip of the catheter is presumed to be situated (HELMSWORTH et coll., RICKLIN, PEIRCE, LINDGREN, SELDINGER, inter alios). The latter three authors have used the percutaneous technique with polythene catheters mainly in lumbar aortography. HELMWORTH et coll. and RICKLIN introduce polythene catheters into the ascending aorta in thoracic aortography. From our experiences in this Department such a procedure is probably not devoid of risk. The tip of the catheter may, for instance, block the orifice of a coronary artery, which would involve danger to the life of the patient.

Since the summer of 1954, we have therefore, tried radiopaque polythene catheters in thoracic aortography. The polyethylene roentgen opaque tubing manufactured by American Cystoscope Makers, Inc. was used in the beginning. This type of catheter, however, did not absorb the radiation to a sufficient degree to be used safely and in a simple manner in thoracic aortography with percutaneous insertion of the catheter. A new type of radiopaque polythene tubing has therefore been devised by the writer in co-operation with Georg Schönander AB, and AB Svenska Metallverken.

This polythene tubing has been used in a new technique of thoracic aortography performed as follows.

The catheter is introduced into the arterial system through the femoral artery by SELDINGER's method. (If catheterization of the ascending aorta cannot be carried out because of coarctation or aneurysm,



a b

Fig. 2. A radiopaque polythene catheter inserted percutaneously into the arterial system through the left femoral artery. The tip lies in the middle part of the ascending aorta. Optimal position for injection of the contrast medium. a. A.p. view. b. Lateral view.

the catheter may be inserted through the right brachial artery by the same technique; Fig. 1.) The catheter is manoeuvred in the arterial system and placed so that its tip lies in the middle part of the ascending aorta (Fig. 2). In this position the contrast medium is injected by means of a pressure apparatus. For thoracic aortography where the catheter is inserted through the femoral artery, a catheter of a special shape is used. Its distal end is distinctly curved, the remainder being quite straight (Fig. 3). With a catheter of this shape the tip may, to some extent, be guided. This is of importance, especially since it has to be introduced from the upper part of the descending aorta through the aortic arch to the ascending aorta. In some cases (postoperative examinations of coarctation of the aorta) the aortic arch may be so severely deformed with sharp bends that if the distal end of the catheter were not distinctly curved, it would be impossible to guide the tip to the ascending aorta (Fig. 4). In addition to the ordinary distal opening, the catheter has side-holes, 0.7 to 0.8 mm in diameter, situated within a distance of 4 to 5 cm immediately proximal to the extremity; these are directed obliquely backwards (Fig. 3). The lumen of the distal opening is sufficiently large as to accommodate exactly the SELDINGER's leader, size PE 160. The remainder of the lumen of the catheter is, however, larger. (Catheters of two different diameters have been used, depend-

ing on the rate at which the contrast solution has to be injected.)

This design of the distal opening and the side-holes of the catheter is necessary to ensure the smallest possible recoil on injection of the contrast medium. Without these measures to soften the recoil, other things being equal, the catheter would be considerably displaced during the injection. This would involve, for instance, the risk of cerebral injury, since toxic doses of contrast solution might enter the cerebral arteries.

The technique outlined has been employed in some 30 cases investigated by thoracic aortography.

Fig. 3. Schematic drawing of the distal part of the catheter. It is distinctly curved. Side-holes immediately proximal to the distal opening. Note the backward directed jets from the former.

No failures have occurred either on catheterising the aorta or in guiding the tip of the catheter to the ascending aorta. Upon injection of the contrast medium the tip of the catheter has not been noticeably displaced, even though the thoracic aorta was dilated (Fig. 5) and the injection performed under relatively high pressure.

As mentioned earlier, two sizes of catheter were used, one having an internal diameter of 1.25 mm and an external diameter of 2.62 mm. This size was employed in most of the examinations. For thoracic aortography 1.0 to 1.2 ml of contrast solution (Umbradil 70 %, or Triurol 50 %) per kg of body weight was used. About 20 ml of solution was injected in a second (JÖNSSON et coll. recommend a rate of injection of 20 to 30 ml per second with RADNER's method). In spite of the relatively slow rate of injection with the technique described, distinct visualization of the whole of the thoracic aorta and its branches was obtained in almost all cases. This may be explained by the fact that owing to the special design of the catheter the injected contrast medium is distributed in the thoracic aorta in a manner advantageous for visualization.

In those cases in which it could be expected that particularly large amounts of blood circulate through the aorta, a slightly larger size of catheter, one with an internal diameter of 1.55 mm and an external diameter of 2.75 mm, was used. This catheter may be introduced into the arterial system through the femoral artery by aid of Seldinger's instrumentarium of size PE 160. For thoracic aortography with this catheter the contrast medium is injected at a rate of 30 to 35 ml per second. The

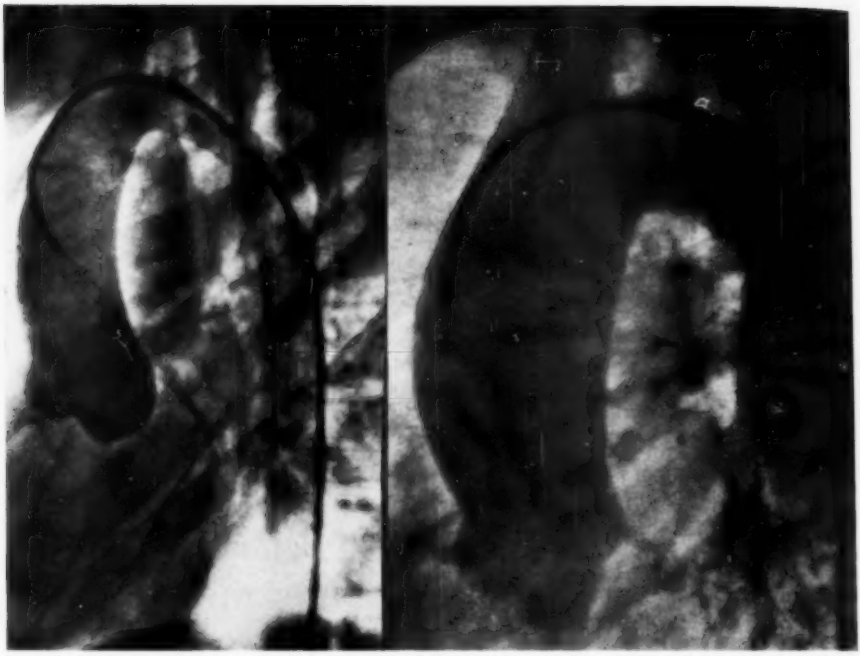


Fig. 4 Fig. 5

Fig. 4. Coarctation of the aorta after operation. Thoracic aortography. The aortic arch is markedly deformed and narrower than normally. A sharp bend at the origin of the innominate artery. The catheter was guided through the arch under fluoroscopic control so that the tip lay in the middle part of the ascending aorta.

Fig. 5. Aortic stenosis. Thoracic aortography. The ascending aorta is dilated (post-stenotic dilatation). The contrast solution was injected at a rate of 20 ml per second. The tip of the catheter was not appreciably displaced during the injection.

total amount of contrast solution introduced has been 1.2 ml per kg of body weight. Examinations with this type of catheter have given satisfactory results in all cases; for instance, patent ductus arteriosus was clearly visualized (Fig. 6).

Complications in the form of relatively large hematomas in the groin about the site of the puncture were observed in the beginning of the series of investigated cases. During this initial period physiologic saline solution, to which heparin had been added, was used for irrigation of the catheter while it was in position in the arterial system. Physiologic saline solution alone was subsequently used for this purpose. Since this change was made the hematomas have been insignificant and have indeed become very rare. On one occasion the needle accidentally per-

Fig. 6. Patent ductus arteriosus. Thoracic aortography; 60 ml of Triurol 50 % injected. Rate of injection about 30 ml per second. Ductus arteriosus is clearly visualized (↑). The pulmonary artery is filled with contrast solution.

forated in two places the femoral artery where it curves at the level of the inguinal ligament. The proximal perforation was not accessible to effective digital compression. As a result, a large hematoma developed in the pelvis and had to be evacuated by surgery. Hence, the femoral artery should be punctured slightly below the inguinal ligament. This will reduce the risk of complications of this kind. No other complications have been observed. It should be stressed that no injuries caused by the injection or the contrast solution itself have occurred.

SUMMARY

A method of thoracic aortography is described. A new type of radiopaque polythene catheter is inserted percutaneously into the arterial system. The tip of the catheter is guided under fluoroscopic control to the middle part of the ascending aorta, where the contrast medium is introduced. Special problems connected with the method described are discussed.

ZUSAMMENFASSUNG

Eine Methode der thorakalen Aortographie wird beschrieben. Ein neuer Typus eines strahlendichten Polythenkatheters wird perkutan in das arterielle System eingeführt. Die Spitze des Katheters wird unter Durchleuchtungskontrolle zum mittleren Abschnitt der Aorta ascendens geleitet, wo das Kontrastmittel injiziert wird. Spezielle mit der beschriebenen Methode zusammenhängende Probleme werden beschrieben.

RÉSUMÉ

Description d'une méthode d'aortographie thoracique. Un cathéter en polyéthylène radio-opaque d'un nouveau modèle est introduit par voie percutanée dans le système artériel. L'extrémité du cathéter est dirigée sous contrôle radioscopique jusqu'à la partie moyenne de l'aorte ascendante où le produit de contraste est injecté. L'auteur discute les problèmes spéciaux relatifs à cette méthode.

REFERENCES

Brodén, B., Hanson, H.-E., and Karnell, J.: Thoracic aortography. Acta radiol. 29 (1948), 181.

Burford, Th. H., and Carson, M. J.: Visualization of the aorta and its branches by retroarterial Diodrast injection. J. Pediat. 33 (1948), 675.

Castellanos, A., and Pereiras, R.: Counter-current aortography. Rev. cubana de cardiol. 2 (1939), 187.

Del Campo, C. G., and Hoyos, J. M.: Angiography of the thoracic aorta and coronary vessels with direct injection of an opaque solution into the aorta. Radiology 50 (1948), 211.

Euler, H. E.: Die peroesophagale Aortenpunktion, ihre diagnostischen und terapeutischen Möglichkeiten. Arch. Ohr-, Nas-. u. Kehlk.-Heilk. 155 (1949), 536.

— Die peroesophagale bzw. pertracheale Kontrastmitteldarstellung des Aortabogens und des absteigenden Aortenschenkels. Arch. Ohr.-, Nas.- u. Kehlk.-Heilk. 155 (1949), 649.

Freeman, N. E.: Contribution to discussion on paper by Gross: Surgical treatment for coarctation of the aorta. J. A. M. A. 139 (1949), 291.

Helmsworth, J. A., McGuire, J., and Felson, B.: Arteriography of the aorta by means of the polyethylene catheter. Am. J. Roentgenol. 64 (1950), 196.

Jönsson, G., Brodén, B., and Karnell, J.: Thoracic aortography. Acta radiol. Suppl. 89 (1951).

Lindgren, E.: Technique of abdominal aortography. Acta radiol. 39 (1953), 205.

Nuvoli, I.: Arteriografia dell'aorta toracica mediante puntura dell'aorta ascendente o del ventricolo S. Policlinico Sez. prat. (1936), 227. Ref. in Zentralbl. f. ges. Radiol. 22 (1936), 382.

Ödman, P.: Percutaneous selective angiography of the main branches of the aorta. Acta radiol. 45 (1956), 1.

Peirce, E. C.: Percutaneous femoral artery catheterization in man with special reference to aortography. Surg., Gynec. & Obst. 93 (1951), 56.

Radner, S.: An attempt at the roentgenologic visualization of coronary blood vessels in man. Acta radiol. 26 (1945), 497.

— Thoracal aortography by catheterization from the radial artery. Acta radiol. 29 (1948), 178.

Ricklin, P.: Percutane retrograde Aortographie. Helv. Chir. Acta 21 (1954), 358.

Seldinger, S. I.: Catheter replacement of the needle in percutaneous arteriography. Acta radiol. 39 (1953), 369.

Stephens, H. B.: Contribution to discussion on paper by Bradshaw, O'Neill and Hightower: Resection of a coarctation of the aorta with subclavian-aortic anastomosis. J. Thoracic Surg. 17 (1948), 221.

Wickbom, I.: Thoracic aortography after direct puncture of the aorta from the jugulum. Acta radiol. 38 (1952), 343.

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THE ROENTGENOGRAPHIC APPEARANCES OF OSTEOID OSTEOMA IN CHILDREN

by

Folke Knutsson

In a publication in 1947, SHERMAN collected 128 cases of osteoid osteoma from the literature and added 30 of his own. Of the total 158 cases, 9 were in the 1—5 year age group and 18 in the 6—10 year group. Thus, although the affection is commonest between the ages of 11 and 25 years, it occurs not infrequently in early childhood.

The characteristic roentgenographic appearances of osteoid osteoma have been described in a number of publications. If the lesion is situated in a long bone the classical picture is characterized by a small rounded nidus with surrounding sclerosis and thickening of the cortical layers. The reactive sclerosis developing around the nidus affects only a part of the circumference of the bone and thus assumes an eccentric appearance.

I do not propose to discuss the pathology of the condition but will concern myself merely with the question of whether the roentgenographic appearances are the same in the child as in the adult or whether any differences exist.

I have had the opportunity of studying a case of a five-year-old girl with osteoid osteoma in both femora. I found that the periosteal reaction in the initial stage was extremely marked and dominated the roentgenographic picture very much more than in the adult. It is only at a later stage when the spindle-shaped thickening and sclerosis of the cortex has developed that the roentgenographic signs in the child and the adult approximate.

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Fig. 1. Right femur. *Above:* First examination. Thick, callus-like deposit around entire circumference of diaphysis; irregular destruction in medial part of cortex. *Below:* Control examinations (3 resp. 10 months later). Periosteal deposits have disappeared; gross spindle-shaped thickening and sclerosis of cortex, the former typically eccentric, being most pronounced in a limited part of the circumference.

A girl, aged 5, was admitted in September 1953 with a limp and complaining of pain in the right hip and leg of 4 months' duration. The pain was at times so severe that the child often wanted to lie down in the middle of the day; of late there had been some tenderness in the thigh. Slightly febrile. Sedimentation rate 50 mm/1 hr.

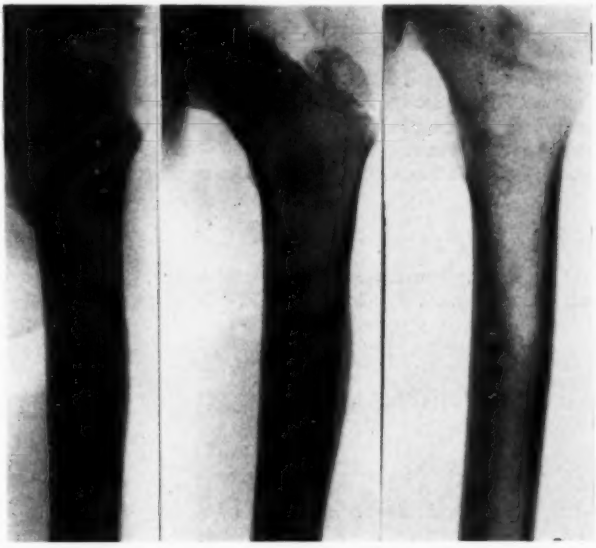
In October, a portion of the right femur was excised for microscopic examination. At operation, a callus-like mass was encountered, surrounding the femur; there was a definite boundary between the periosteal process and the underlying bone.

Microscopic examination: Osteoid osteoma. Tumour tissue consisting mostly of calcareous bone trabeculae of irregular architecture, the medullary spaces fibrotic with typical layers of osteoblasts and isolated osteoclasts. In some areas denser and more slender trabeculae of osteoid tissue. No evidence of malignancy.

In January 1954 there was no pain and the child no longer limped. Sedimentation rate 8 mm/1 hr. The patient did not at any time complain of pain in the left leg.

This case shows that the periosteal process may be extremely extensive (right femur) embracing the entire circumference of the bone. Brisk periosteal activity is probably to be expected in the young. The eccentricity so characteristic of osteoid osteoma appears only at a later stage when the sclerotic thickening of the cortex has developed. The process was associated with pain during the 'periosteal' stage but the patient was quite symptom-free during the subsequent 'sclerotic' stage.

The lesion in the left femur presented the usual appearances with a small focal destruction in the cortex and surrounding periosteal reaction. The cortex was typically sclerosed and thickened around the nidus. At a sub-



a b c

Fig. 2. Left femur. a. First examination: Periosteal deposits on a small part of circumference; spindle-shaped thickening and sclerosis of cortex. Central focus of destruction. b. Control examination 3 weeks later. The lesions have progressed. c. Control examination 8 months later. Periosteal deposits and nidus have disappeared; both thickening and sclerosis of cortex diminished.

sequent control the nidus had disappeared and the sclerosis diminished, the process thus showing spontaneous regression. This lesion was also painless throughout its course.

SUMMARY

A case of osteoid osteoma of the femora in a five-year-old child is described. On the left side a characteristic nidus with local periosteal reaction and sclerosis was present. The process regressed spontaneously. On the right side the periosteal reaction in the initial stage was extensive and embraced the entire circumference. The subsequent thickening of the cortex had the characteristic eccentric appearance.

ZUSAMMENFASSUNG

Ein Fall eines osteoiden Osteomes in einem kindlichen Femur wird beschrieben. Im linken Oberschenkel lag ein charakteristischer Herd mit lokaler periostaler Reaktion und Sklerose vor. Der Prozess bildete sich spontan zurück. Im rechten Oberschenkel war die periostale Reaktion im Initialstadium bedeutend und umfasste die ganze Zirkumferenz. Die nachfolgende Verdickung der Cortex hatte das charakteristische exzentrische Aussehen.

RÉSUMÉ

L'auteur présente un cas d'ostéome ostéoïde des fémurs chez un enfant de cinq ans. Du côté gauche il existait un nid caractéristique avec réaction périostée locale et sclérose. La lésion régressa spontanément. Du côté droit la réaction périostée au stade initial était étendue et embrassait toute la circonférence de l'os. L'épaississement consécutif de la corticale avait l'aspect excentrique caractéristique.

REFERENCE

SHERMAN, M. S.: Osteoid osteoma. Review of the Literature and Report of thirty cases. J. Bone and Joint Surg. N. S. 29 (45) (1947), 918.

FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR: PROF. K. LINDBLOM), KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

THE ROENTGENOGRAPHIC APPEARANCE OF INJURIES TO THE INTERVERTEBRAL DISCS

by

Åke Lindbom

A vertebral fracture of the usual type with compression of the vertebral body is frequently accompanied by an injury of the adjacent intervertebral disc. In order to study the roentgenographic end-stage of traumatic disc ruptures I have reviewed the roentgen films of 34 patients who sustained a vertebral fracture of the type mentioned. Repeated roentgen examinations had been made in all cases.

In 22 of these cases a narrowing of the intervertebral space adjacent to the fracture occurred in connection with the trauma. This reduction of the intervertebral distance was regarded as a sign of disc rupture except in three instances in which the upper or lower surface of the vertebral body in question was seen to be fractured. In 17 out of these 19 cases in which a disc was ruptured, calcifications appeared around the disc, and were mainly situated along its lateral margins. In several of the cases no reduction of the height of the disc was apparent at the first examination made directly following the trauma but was seen only at subsequent examinations.

HANSEN and OLSSON showed that a single violent trauma to the back of the dog will more often result in a fractured vertebral body than rupture of a disc. This tendency was more marked in young than in old dogs.

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Table I shows that a similar tendency was discernible in human subjects. In approximately one third of the cases no disc lesion, *i. e.* gross change with compression of the disc, was shown. The fractures without disc lesions, were found mainly below 30 years of age. It is thus probable that heavy trauma to the spine more often causes a fracture than a disc lesion and this tendency is more pronounced in young subjects.

Table I

Vertebral fractures (mainly 1st and 2nd lumbar) examined in connection with, and at least three months after, trauma

	Calcifications around disc	Fracture of plate with protrusion of disc into body	< 30 years	> 30 years	Total
Intervertebral space adjacent to fracture in end stage					
reduced	17	3	4	18	22
not reduced	0	0	11	1	12
					34

Isolated injuries to discs should therefore be infrequent and this is in accordance with the views generally held. Such lesions do, however, exist. The author has observed three cases:

Case 1 (Fig. 1). Male aged 20; trauma: fall; calcification visible 11 days after trauma; disc injured: C. 6.

Case 2 (Fig. 2). Male aged 30; trauma: fall when skiing; calcifications visible $3^1/_2$ months after trauma; disc injured: L. 2.

Case 3. Male aged 45; trauma: small house collapsed on patient; calcification visible $2^1/_2$ months after trauma; disc injured: L. 2.

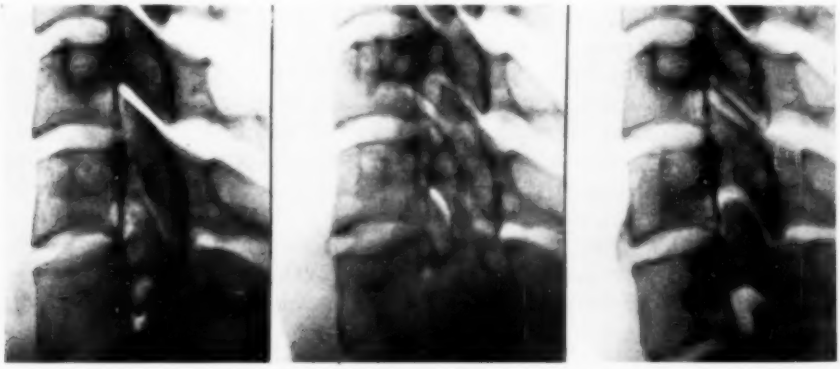

Fig. 1. Disc injury. *Left:* Immediately following trauma. No changes visible. *Middle:* 11 days later, thin calcifications are visible. *Right:* 3 months after trauma.

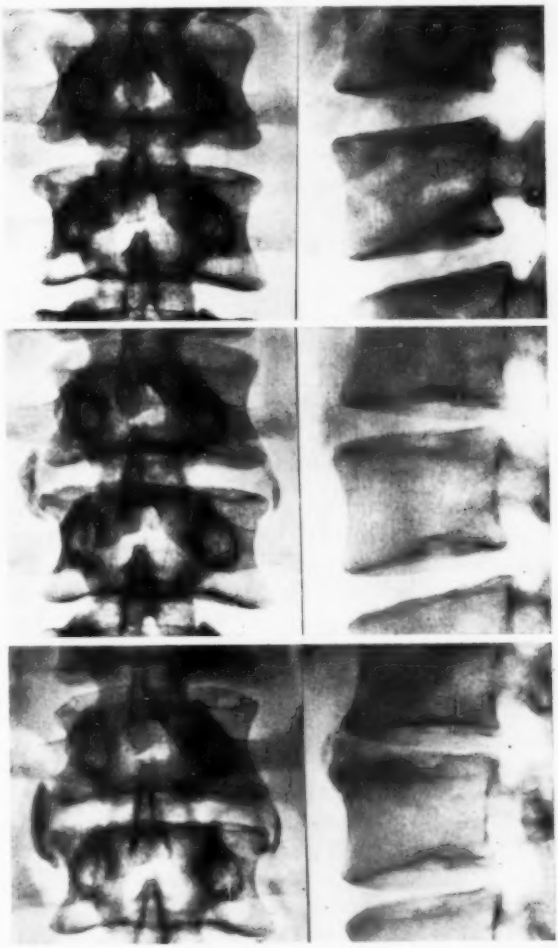

Fig. 2. Disc injury. *Top:* Immediately following trauma. No changes visible. *Middle:* $3^1/_2$ months later, the height of the disc is reduced and calcifications have appeared. *Bottom:* Two years after trauma.

In none of these cases were any roentgenologic changes visible at the site of the subsequent lesion when the patient was examined directly after the trauma. In Case 3, a fracture of a small portion of the anterior lateral margin of the lower vertebra was overlooked at the first examination. The lesion was regarded as mainly a disc injury.

Conclusions

Traumatic lesions of intervertebral discs without concomitant vertebral fracture are probably rare. In such cases roentgenologic changes may be absent at the examination directly after the trauma. The height of the disc is subsequently reduced and calcifications appear around the disc mainly along its lateral margins.

SUMMARY

An analysis of 34 cases of vertebral compression fractures with special reference to injuries of vertebral discs is presented. Three cases of isolated disc injuries are reported.

ZUSAMMENFASSUNG

Eine Analyse von 34 Fällen mit Kompressionsfrakturen der Wirbelsäule mit besonderer Berücksichtigung der Schäden der Zwischenwirbelscheiben wird vorgelegt. Drei Fälle von isolierter Scheibenverletzung werden beschrieben.

RÉSUMÉ

L'auteur présente une analyse de 34 cas de fractures vertébrales par compression et insiste particulièrement sur les lésions des disques intervertébraux. Trois cas de lésion isolée de disque sont relatés.

REFERENCE

HANSEN, H. J. and OLSSON, S. E.: The effect of a single violent trauma on the spine of the dog. Acta orthoped. Scandinav. 24 (1954), 1.

FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR: PROF. KNUT LINDBLOM), KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

A MOVING VERTICAL GRID SUITED FOR VERY SHORT EXPOSURES

by

Ove Mattsson

Stationary grids are widely used for routine work, for example, in upright screening stands (such as of the Forssell type) or in association with undercouch tubes. The visible grid pattern in the resultant films has, up till now, been regarded as an inevitable disadvantage, although not a very serious one. In view of the fact that uniform and small-spaced grids have been manufactured during recent years, it is not surprising that the grid pattern has generally been regarded as a factor without much influence on the resolution of detail (G. SCHÖNANDER 1941). Interest in film detail has recently grown, and — perhaps in part through the introduction of small tube foci — grid pattern has become less tolerable. The truly disturbing effect of grid pattern on the resolution of detail has perhaps scarcely been given sufficient consideration. The present author has discussed the question in detail in other connections (MATTSSON 1955), and only brief comments will now be made.

The grid elements cover a not unimportant portion of the roentgenogram, and the eye is irritated by the break in continuity. M. LUCKIESH (1945), for instance, demonstrated, in connection with the physiologic problems of film evaluation, that observation is generally made difficult by the inclusion of a pattern. Thread-like objects, such as vessels, not infrequent in roentgenography, are liable to suffer particularly since they may coincide with the grid elements. Through interference with the grid pattern, certain fine detail may also easily be suppressed or exaggerated, and a distortion of contours produced. Phantom tests on the visibility of details have been made, inter alia, with cross-grids, and show there is a

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distinct loss in comparison with a pattern-free film produced with the same grid in motion.

It seems a logical development that we should try to eliminate grid pattern as completely as possible and introduce moving grids wherever stationary grids are still in use. Any improvement in the delineation is a mere illusion as long as the grid outline is included in the film.

Incidentally, it should be noticed that the disadvantages of the grid have frequently been avoided. This is particularly the case in roentgenography of the chest; it is common knowledge that chest specialists are most unwilling to tolerate the use of grids. In our ordinary work, however, we cannot usually avoid their employment. The technique of an increased object—film distance, with a consequent reduction in secondary radiation on the film, has found more frequent employment through fine focus tubes and has also been utilized for direct magnification. This technique may also be seen as an attempt to avoid the use of a grid.

Certain special units for the screening of patients erect, such as the Scopograph (Philips) and the Explorator (Siemens) have incorporated grid motion mechanisms. Of these, the first was equipped with a spring-suspended oscillating grid based upon a principle similar to the one described by W. Watson (1945).

The ultimate object is a handy, simple, and reliable drive-mechanism, which must not only be adaptable to the upright screening stand, but also capable of being combined with an undercouch tube as well as with film changers. It must meet the demands made by modern high-voltage technique with extremely short exposures. Its design must eliminate visible striping in the film, produced by stroboscopy. In this respect many previous mechanisms do not appear to have been entirely satisfactory.

The new drive-mechanism was first tried in screening units. The next development will be concerned with couches and film changers. The basic principle will remain unchanged. For film changers, however, special considerations will be necessary, since the mechanisms have to be synchronized with the motion of the film changer, for instance through a flexible shaft. The author hopes to return to these problems in the future. It seems natural to start with vertical grids in screening equipment, since the special working conditions of these make the problems more acute. The screen and the grid must show an extreme degree of mobility, and the compression technique in the examination of the stomach must not be made difficult.

A short description of the principle may be of interest. Electrically operated mechanisms have largely been used. Liebel-Flarsheim developed a mechanism based on the forces exercised by a solenoid, and electric motors with eccentrics transmitting the motion to the grid have been used

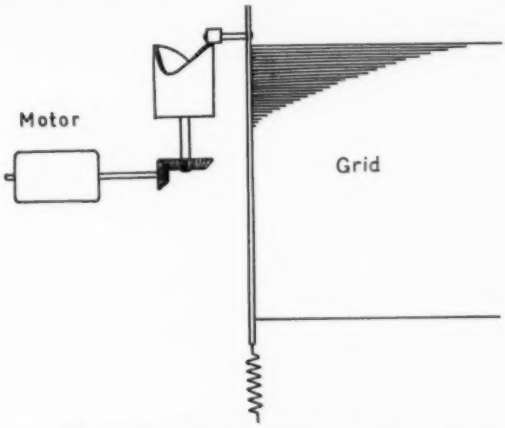


Diagram 1. The mechanical principle of the vertical moving grid.

for many years. In a study of grid problems (MATTSSON 1955), the author has already stressed the importance of *constant* speed of the grid, with due regard to the effects of stroboscopy. The speed must be carefully adjusted to a level suitable for the grid size and the current curve. This fact makes a steering of the motion along a specific curve the most suitable proposition. The nature of the principle, the mechanical solution of which emanates from Siemens, is shown in Diagram 1.

The electric motor, of a type similar to those used in automobile windscreen wipers, drives a steering cylinder, the axis of which lies parallel with the motion of the grid. The cylinder has a curved groove in which runs a kind of slide connected with the grid. The steering is controlled by a spring. The rotation of the cylinder produces two different motions of the grid: a slow rising motion and a very rapid falling motion. Diagram 2 illustrates the pattern of motion. Limit switches are used to start the exposure at the most suitable moment, and the resting position is such that the retardation in the exposure is practically negligible. Exposure at the turning points is avoided as far as possible for, as the author has stressed previously, this is a source of striping in the film. By employing two fixed motor speeds together, satisfactory movement of the grid may be produced for all exposures. Of particular interest is the rapid motion, which permits roentgenograms free from pattern at an exposure time as short as 0.01 sec with a four-valve unit, corresponding to an effective time of 0.004 sec. Even with this exposure time, the grid

Diagram 2. Illustrating pattern of motion. A slow and a rapid stroke alternate.

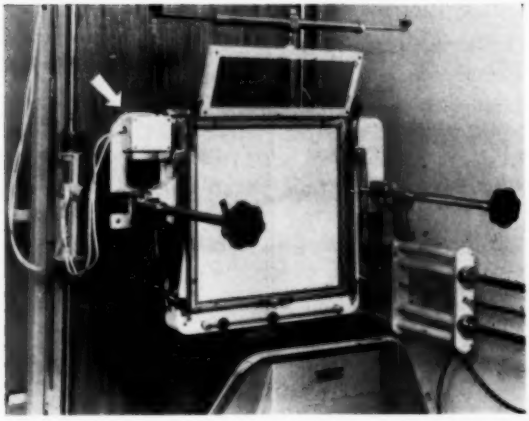


Fig. 1. Grid mechanism attached to Forssell stand. Motor and transmission indicated by white arrow.

pattern is completely effaced, a result which has not so far been possible. The gradual development and adjustment of the apparatus has been made on an upright stand of the Forssell type in our Department during heavy routine work and with a constant critical attitude towards the pictorial results obtained.

Photographs of the apparatus will help to clarify its construction. Fig. 1 shows the apparatus attached to the Forssell upright stand. Motor and transmission are indicated by an arrow. The compactness and simplicity of the mechanism are evident. Fig. 2 gives a side-view of the mechanism. The handle-shaped locking device for the sliding motion of the screen frame on the horizontal bars is seen at the bottom. The fitting of the grid arrangement has not materially increased the thickness of the screen frame. Fig. 3 shows the apparatus as seen diagonally from behind. A plexiglass plate, slightly convex, forms an elastic stop in the compression action during stomach examinations, contact between the plate and the moving grid which might retard the motion of the latter being prevented. Fluoroscopy is not interfered with in any way, and the mobility of the screen is not impaired.

The grid mechanism is controlled automatically from the control table. There is no need for adjustment of time, nor any setting of springs. The release mechanism is completely automatic.

The moving grid unit has been in use in daily routine work for about six months. Figs. 4 a and b show the different appearances of films of the apex of a lung obtained with an ordinary stationary grid and with the new moving grid. Although the conditions of contrast may not be

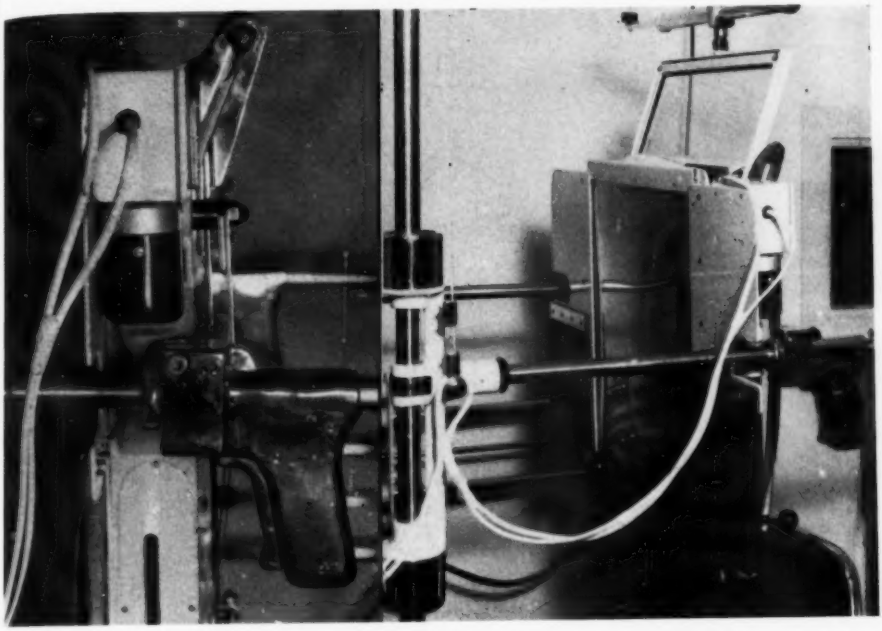
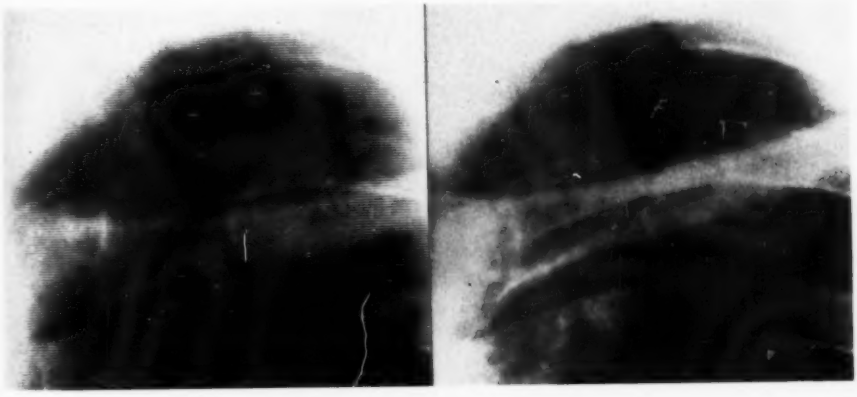


Fig. 2. Side-view of mechanism. The grid frame thickness has not been substantially increased.

Fig. 3. Apparatus diagonally from behind. Note slightly curved plexiglass plate; an elastic stop is formed in compression.



a b

Fig. 4. Films of apical region of lung. Obtained with: a) ordinary stationary grid, b) with new grid.

Fig. 5. Detail of chest film at 150 kV and 0.01 sec (less than 0.004 sec effective).

quite comparable — the two grids differ in efficiency — the films are fairly comparable as regards other factors; they are meant only to show the effect of grid pattern. Apart from the richness of detail, Fig. 4 b appears more agreeable to the eye than Fig. 4 a.

A detail of a chest film made at 150 kV with a four-valve apparatus is shown in Fig. 5. The exposure was timed at 0.01 sec (corresponding to 0.004 sec effective). During the short exposure peak the grid is seen to have moved sufficiently to produce complete freedom from pattern. The short exposure time was obtained by using an apparatus equipped with current valves (Ignitrons) permitting switching of only one half-wave. Fig. 6 is a roentgenogram of a stomach, demonstrating the mucous membrane under moderate compression. The voltage used was 140 kV and the time 0.05 sec. A film of a contrast-filled gallbladder with a number of small stones at the fundus is reproduced in Fig. 7. This was obtained with a much lower kilovoltage (80 kV) and longer time than the others.

Fig. 6. Mucosa of stomach under moderate compression (140 kV and 0.5 sec).

Fig. 7. Filled gall-bladder with stones at fundus (80 kV and 0.20 sec).

A grid with a ratio of 1 : 8, centered for 110 cm, was employed. It was found to be much better suited for high-voltage than previous stationary grids, which usually have a much lower ratio. The choice of ratio and centering seems to be well suited for apparatus of the type used. The grid performed satisfactorily at the voltages and focal distances (70 to 150 cm) encountered. In exposing small films, centering may largely be neglected and the lower part of the frame utilized.

In conclusion it may be stated that the apparatus permits the elimination of grid pattern in examinations in which previously a stationary grid was the rule, and that it extends the possibilities of the high-voltage technique.

The practical development and the clinical testing of the design was made in cooperation with G. A. Magni. The mechanical construction work was carried out by AB Elema jointly with Siemens.

SUMMARY

The author describes a grid mechanism for vertical stands with a reciprocating motion permitting exposures down to 0.01 sec with a four-valve unit, without visible grid pattern on the film.

ZUSAMMENFASSUNG

Der Verfasser beschreibt ein Raster für Vertikalstative mit einer oszillierenden Bewegung, die Exponierungen bis auf 0.01 Sek. hinunter mit einem 4-Ventilapparat ohne sichtbare Rasterlinien ermöglicht.

RÉSUMÉ

L'auteur décrit un mecanisme moteur de grille pour statifs verticaux à mouvement oscillatoire permettant des poses jusqu'à 0.01 sec. avec un appareil à quatre soupapes sans dessin de grille visible.

REFERENCES

Luckiesh, M.: Light, vision and seeing. D. van Nostrand Comp., New York 1945.

Mattsson, O.: Practical photographic problems in radiography with special reference to high-voltage technique. Acta radiol. Suppl. 120 (1955).

Schönander, G.: A study of secondary screening. Acta radiol. 22 (1941), 796.

Watson, W.: An oscillating grid. Radiography 11 (1945), 22.

FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR: PROF. OLLE OLSSON), OF THE UNIVERSITY HOSPITAL OF LUND, SWEDEN

TOLERANCE TO CONTRAST MEDIA IN RENAL ANGIOGRAPHY

by

Hans Idbohrn

Since the introduction of abdominal aortography by DOS SANTOS, LAMAS & CALDAS in 1929, the examination, especially as renal angiography, has received much interest in the literature. In the beginning the contrast media used consisted of compounds containing inorganic iodine, particularly sodium iodide in 80 to 100 per cent concentration. The examination was, however, sometimes accompanied by serious side-effects, which limited the use of the method. These contrast media are, however, no longer employed. Nevertheless, as late as 1955, RITTER recommended the use of such a contrast medium, a recommendation which, in view of the wide selection of organic contrast media now available, is not justified. Organic contrast media have been widely used for renal angiography and, according to many authors, involve but little risk of toxic injury even when inadvertently injected directly into the mesenteric or renal artery (SMITH, RUSH & EVANS 1951, DOSS 1952, POUTASSE, ENGEL & ROOT 1952, SMITH, EVANS, ELSEY & FELSON 1952, HAMM & HARLIN 1953, etc.). Nor did DENSTAD (1952), BERRY, WHITE & METCALFE (1952), HOOKS & GRAVES (1952), SMITH (1953), MALUF & MCCOY (1955) and others observe any significant side-effects.

TRAUTNER & PAHLE (1954) carefully studied renal function before and after renal angiography in 9 patients. They also examined the patients on both occasions with respect to body temperature, pulse, blood pressure, urinary output, urinary sediment, plasma CO_2 and serum chlorides, serum proteins, Addie's test, blood urea, and 24-hour creatinine clearance. In 1 of the 9 cases the creatinine clearance was found to have decreased from 101.2 ml/min the day before the renal angiography to

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86.0 ml/min afterwards. They nevertheless claimed that as long as renal function is normal or only moderately lowered, renal angiography may be performed without undue risks.

Undesired reactions to contrast media were reported by LARSSON & PALMLÖV (1952) and HARVARD (1953) who occasionally observed slightly decreased renal function after renal angiography. A similar but more pronounced reaction was observed by LINDBLOM & SELDINGER (1955) in 3 patients with renal arterial sclerosis or pyelonephritis. Their series consisted of 139 cases. MILLER, WYLIE & HINMAN (1954) reported serious but transient renal injury in 7 out of 250 cases. In 3 of their cases the injury was unilateral and according to them due to too rapid injection of the contrast medium directly into the renal artery or into an aberrant vessel. In one of these 3 cases the kidney became slightly atrophic and in another case there was temporary cessation of renal function (on the same side) with hypertension. In the other 4 cases the injury was bilateral and was followed by 10 to 11 days anuria or oliguria as well as a pronounced increase in the NPN. In all of these 7 cases the patients had received fairly large doses of contrast medium (50 to 70 ml and in 1 case 50 + 50 ml) of Diodrast 70 %. In a series of 32 patients submitted to renal angiography THOMSEN & HANSEN (1954) observed renal injury in 3. In 2 of them who had received 40 ml diodone 70 % and 50 % respectively the blood urea increased to 100 to 150 mg/100 ml. In the third case, in which the dose consisted of 60 ml of diodone 70 % the issue was fatal. They did not describe the indications for renal angiography, nor did they say where the contrast medium was injected in relation to the origin of the renal arteries. They only pointed out that renal function two months earlier was impaired and that urography at that time showed only slight excretion of contrast medium. Post-mortem examination revealed pronounced vascular changes with a narrowing of the aorta below the origins of the renal arteries which contained fairly fresh thrombi and showed evidence of advanced endarteritis which was also present elsewhere. It is evident that in this case renal angiography was contraindicated by the clinically known presence of renal failure. In a case described by KUNLIN, BITRY-BOELY & VOLNIE (1950) in which the injection of 50 ml of Diodrast 70 % had a fatal effect, the examination was contraindicated by the poor general condition of the patient. In a patient with hypertension and reported by JOSSELSON & KAPLAN (1954), translumbar aortography with 15 ml Neoiopax 75 % was followed by a fatal reaction. The contrast medium had been injected close to the origin of the artery to the only functioning kidney, the contralateral kidney having shrunken because of pyelonephritis. Renal function was decreased before the examination and the urine contained albumin. The patient died in uremia 26 days after the examination. Post-mortem examination revealed chronic

pyelonephritis as well as pronounced toxic injury to the glomeruli and tubules on one side, and extensive nephrosclerosis on the other side. The impairment of renal function should have been regarded as contraindicating renal angiography. The severity of the injury was probably due to the high concentration of the contrast medium and to the fact that the major portion was injected into the only functioning kidney.

JOHNSSON & NORRMAN (1954) described lower nephron nephrosis following renal angiography in a 63-year-old woman who, at the age of 4, had had nephritis which had healed without signs of impairment of renal function. Intravenous urography had revealed an expansive process in one of the kidneys. Transfemoral renal angiography with 30 ml Umbradil (Diodonium) 70 % showed the process to be a cyst. During the injection the tip of the catheter was 4 cm below the origin of the renal arteries. On re-examination of the original roentgenograms the amount of contrast medium injected appeared to have been large and the medium to have flowed an unusually long distance in a retrograde direction into the aorta, suggesting decreased blood pressure. It was also apparent that contrary to what had been noted in the records, excretion of the contrast medium had not started 7 seconds after the injection (OLLE OLSSON 1955). Initial signs of renal injury began to appear within 24 hours — albuminuria, microscopic haematuria, oliguria, increased NPN, and water retention as well as chloropenia, mild acidosis, anemia, an increased erythrocyte sedimentation rate, and a slight increase in the blood pressure. The NPN, which reached a maximum of 97 mg/100 ml on the eleventh day, gradually returned to normal 4 weeks after the injection. The specific gravity of the urine from 24 hour samples varied between 1.002 and 1.007. The only sequel observed on review four and a half months after renal angiography was decreased concentrating power.

In a series of some 200 cases RICHES & GRIFFITHS (1955) observed transient but severe renal injury in a middle-aged man in whom urography had revealed nothing of interest. Translumbar aortography with 30 ml diodone 70 % was done because of a suspected tumour. Some of the contrast medium was deposited into the wall of the aorta. A second equally large quantity was then injected, and the roentgenogram showed no signs of a pathologic condition. The examination was followed by 6 days' anuria. The blood urea increased and reached a maximum of 245 mg /100 ml on the fifth day, after which it decreased to reach a normal level on the thirteenth day.

ALWALL, JOHNSSON, TORNBERG & WERKÖ (1955) published a survey of 8 cases of renal injury following angiography including 5 following renal angiography; these 5 cases include the one referred to above (JOHNSSON & NORRMAN). Two (2) cases belong to the present material (and

are described later in this paper), leaving 2 in which the patients died in uremia.

In one of these 2 latter cases urography and retrograde pyelography had revealed a small papilloma of the renal pelvis. Urograms taken some time later had shown the same state of affairs; the same day the patient was submitted to translumbar aortography for which he received 2 injections of 30 ml Umbradil 70 %. The first dose was deposited almost entirely in the artery on the healthy side. After further aortic puncture cranial to the first, the second dose was injected and passed, apart from other regions, into both kidneys. On the day of nephrectomy, 72 hrs later, the NPN was normal. The operation was followed by oliguria and increased NPN. Hydration and a mercurial diuretic only made matters worse and despite treatment in the Renal Department of the Medical Clinic at Lund the patient died 6 weeks later of uremia and pneumonia. Post-mortem examination showed advanced tubular nephritis in a state of regeneration. The remarkably large number of injections of contrast medium at such short intervals had probably led to renal functional impairment, not manifest until after nephrectomy. However, the possibility of the renal failure being due to nephrectomy cannot be excluded. In the other case, the urograms suggested the presence of an expansive process in one of the kidneys. Renal angiography 2 weeks later with 50 ml sodium acetrizoate (Triurol, Leo) 70 %, however, showed no signs of a pathologic condition. The examination was followed by practically complete suppression of urinary excretion and a little more than 1 month later the patient died in uremia. Post-mortem examination showed healing tubular nephritis and pyelonephritis with abscesses.

In a personal communication WEYDE (1955) described two cases of renal injury after renal angiography with Nycotrast (diodone) 70 %.

One of the patients was a woman, aged 38, with hypertension. Because of suspected pheochromocytoma, translumbar aortography was performed, two 30 ml doses of contrast medium being deposited at the level of the origin of the renal arteries. The nephrographic effect was more marked than usual, especially on the right side. Even 20 minutes after injection, both kidneys, but especially the right, still showed an accumulation of contrast medium. Before the injection the blood pressure was 230/140 mm Hg, as against 140/115 mm Hg the following day as well as throughout that week; it then fluctuated between 170/130 mm Hg and 155/125 mm Hg. The temperature increased to about 39° C after the examination, and then gradually returned to the original value during the following 5 days. The NPN increased from 23 mg/100 ml before angiography to a maximum of 155 mg/100 ml 4 days later. After a further 2 weeks the NPN was normal. The ESR was 14 mm/hour before the examination and increased to a maximum of 111 mm 5 days after the angiography. Four weeks later the ESR was 20 mm. For about 2 weeks the urine, which had previously been normal, contained traces of albumin and single red blood cells, but no casts. The urea clearance, as determined 8 months before the examination, was, at the most, 35 % and 74 %, respectively. Eight days after the angiography the corresponding value was 20 % for both tests and after a month 21 % and 24 %, respectively. After this examination renal impairment was for a time still more severe.

The other patient, a man aged 47, was examined angiographically for renal tuberculosis, the examination being performed by transfemoral catheterisation. However, during injection of the contrast medium the tip of the catheter lay in the lower branch of the left renal artery. The nephrographic effect in the lower half of the kidney was intense. The contrast medium persisted in the renal parenchyma for about 5 hours after the injection, and a part lay subcapsularly round the lower pole of the kidney. The patient had no pain.

The urine contained a small quantity of albumin and granular and hyaline casts, still seen 1 week later. The NPN was not increased. Control urography about 2 weeks after angiography showed that excretion by the injured kidney was retarded, but after a further week was as good as on the other side. Operation about 4 weeks after angiography revealed a large infarct in the lower part of the left kidney which was removed, because the tuberculous lesion was situated in the upper part of the kidney. Pathology report: Renal infarct with proliferative endarteritis in the demarcation zone. (This case will be described in detail by ARNESEN, BRUUSGAARD & WEYDE.)

After 40 aortographic examinations without complications LODIN & THORÉN (1955), using hypotension as proposed by LINDGREN (but produced by tetraethyl ammonium bromide), observed a case of temporary renal failure. In that case 40 ml Umbradil 70 % was injected through a catheter. The NPN was, at the most, 110 mg/100 ml on the 5th day. About 4 weeks later, a kidney was removed for hypernephroma and the post-operative course was uneventful. After this complication LODIN & THORÉN performed renal function tests before and after aortography in all of the 15 cases recorded. The tests were done on the two days preceding aortography and on the first, second, third, and seventh day, following it. The tests applied were Heller's test for albuminuria, Esbach's test when indicated, specific gravity of first morning specimen, Addie's test, and determination of the volume of urine excreted in 24 hours. The blood was examined for NPN daily and the serum protein, serum chloride, and serum bicarbonate, before the examination and on the third day following it. Creatinine clearance tests were carried out and the blood pressure was recorded. In 3 cases there was a slight fall in creatinine clearance after aortography, but in 3 other cases a slight increase was noted. The mean values found for the various renal function tests were otherwise almost the same before aortography as following it.

Author's material

It is apparent from the survey of the literature that renal angiography is widely accepted as a relatively safe method, although serious side-effects can occur. It appears that these latter have not been systematically investigated in a representative series examined both before and after angiography. It was therefore thought that such an investigation might be of interest.

The tolerance of the patients to contrast media used in various types of roentgenologic examination including renal angiography has received considerable attention in our department.

Before angiography and on each of the three days afterwards, the serum NPN was determined, the urine examined for albuminuria (Heller's test) and, in the present series, the urinary sediment was examined microscopically. This has been the rule since 1951, when angiography began to

find wider clinical use. In addition, since the observation of a case of distinct but transient renal enlargement after the examination, the size of the kidneys is assessed from conventional roentgenograms taken on each of the first 3 days following angiography. This material consists of 200 cases, but some of the patients were not examined by all of the control methods described above.

Non-protein nitrogen. Of the 186 cases in which the non-protein nitrogen was determined before and 3 days, in a few cases 2 days, after angiography, an increase was noted in 10 (Table I), in 8 of which it was only slight. Of these 8 cases, Umbradil 50 % was used in 2, Umbradil 60 % in 4, and Triurol 47 % in 2. In 2 cases in which Umbradil 60 % was employed, the NPN increased to 102 mg/100 ml and 87 mg/100 ml, respectively. These 2 cases are of particular interest and are described in detail.

Table I

Material

Method	NPN increase		Albuminuria (Heller's test)		Cylindruria		Renal enlargement	
	max. 50—60	max. 85—105	weakly positive	positive	single	moderate	slight	distinct
Transradial renal angiography Umbradil 50 %	2/15	0	0/16	0	0/14	0	—	—
Transradial renal angiography Umbradil 60 %	3/39	0	1/39	2/39	8/38	0	—	—
Transfemoral renal angiography Umbradil 50 %	0/1	0	0/1	0	0/1	0	—	—
Transfemoral renal angiography Umbradil 60 %	1/69	2/69	0/62	7/62	5/68	1/68	4/34	1/34
Transfemoral renal angiography Triurol 35 %	0/1	0	0/1	0	0/1	0	—	—
Transfemoral renal angiography Triurol 47—52 %	2/61	0	2/53	32/5	3/49	0	5/54	0
Number of cases (pos. findings)	8/186	2/186	3/172	11/172	16/171	1/171	9/88	1/88

Case 1. A boy, aged 9, with nocturnal enuresis since birth. Urography in August 1953 showed hypoplasia of the right kidney (5.5 cm by 2 cm) with compensatory enlargement of the left kidney (11 cm by 5.5 cm). Contrast excretion: left side normal, right side slightly delayed. Three weeks later: transfemoral renal angiography with 22 ml Umbradil 60 %. The catheter was passed up the aorta until the tip was about 1.5 cm caudal to the origin of the left renal artery. The left kidney was well vascularized. The right renal artery was narrow and the nephrographic effect in the kidney decreased; in view of the position of the tip of the catheter and the rich vascularization of the left kidney, a relatively large amount of contrast medium of high concentration was deposited in this kidney. As the contrast medium was injected under general anesthesia (chlorethyl + ether) and curarisation (scoline) the patient was told to abstain from fluid and food

some hours before the examination, but the instruction was misunderstood so that he neither ate nor drank anything for 18 hours before the examination. Anesthesia was uncomplicated. The blood pressure was 100 mm Hg. After angiography the general condition of the patient was good, but the day afterwards, nausea, vomiting, oliguria, and proteinuria occurred, and the urinary sediment was abnormal. The serum NPN increased to a maximum of 102 mg/100 ml and the diastolic blood pressure was slightly elevated. After 3 weeks the NPN and the blood pressure had returned to normal. Conventional roentgenograms of the kidneys taken during the stage of uremia revealed renal enlargement (left: 13 cm by 6.5 cm; right 6.5 cm by 2.5 cm). This enlargement gradually diminished and on control roentgenography on the thirty-eighth day after the examination, it had disappeared. Two and a half months after angiography the concentration capacity was 1.022, maximum.

Transfemoral renal angiography in a boy with unilateral renal hypoplasia was followed by renal injury of the type seen in tubular nephritis. The injury was most advanced about 1 week after the examination, after which renal function gradually recovered. The most persistent change was a slight decrease in concentration capacity. It should, however, be mentioned that the sample was collected from the bladder urine, a mixture of urine from both kidneys. The injury might have been due in part to the prolonged (at least 18 hours) withdrawal of fluid and the relatively large amount of contrast medium deposited close to the origin of the artery of the compensatorily enlarged contralateral kidney.

Case 2. A woman, aged 58, with many years' history of hypertension. Five months before angiography routine roentgenograms of the kidneys had revealed no signs of a pathologic condition and the maximum concentration capacity was good. She was admitted to hospital because of increasing dull pain in the left hip. During her stay a pathologic fracture of the femoral neck was diagnosed. Search for the site of the primary tumour included transfemoral renal angiography, which revealed a small tumour in the left kidney. At angiography with 30 ml Umbradil 60 %, the filling of the renal arteries was incomplete. The catheter was passed further up the aorta and about half an hour after the first injection a second dose of 30 ml was injected. The examination was carried out under general anesthesia (Narcotal + N_2O) and curarisation (Scoline). During the anesthesia, the blood pressure fell from 240 mm Hg to 190 mm Hg after the first injection but after the second injection rose to 240 mm Hg; at the end of anesthesia which had been maintained for 50 minutes, the blood pressure was 150 mm Hg; anesthesia was otherwise uneventful. After the examination the output of urine decreased and the NPN increased to reach a maximum of 87 mg/100 ml a week later and returned to normal after a further three weeks. The first week after the angiography the patient had albuminuria and 3 days after angiography the urinary sediment contained many white blood cells and fair number of red blood cells although other samples showed only a varying number of white blood cells and 0 to 3 red blood cells. No cylinders were seen. The renal injury was not accompanied by symptoms. Thirty-two days after angiography the patient was subjected to nephrectomy. The operation and the post-operative course were uncomplicated. (This case has been described by LÖFGREN 1954.)

This patient received 2 injections of 30 ml Umbradil 60 % within half an hour owing to an unsatisfactory position of the tip of the catheter

during the first injection. Renal injury with moderate increase in the NPN not accompanied by symptoms was noted. Nephrectomy was postponed 1 month, but the course was otherwise favourable.

Albuminuria. Heller's test was positive in 9 cases and weakly positive in 1 in which Umbradil 60 % had been used. The test had been positive in 2 and weakly positive in 2 after the use of Triurol 47 to 52 %. The total number of examinations was 172, Umbradil 50 % being used in 17, Umbradil 60 % in 101, and Triurol in 54 (Table I). When urine containing contrast medium is examined for albuminuria by Heller's test, flocculation can sometimes occur. This may mask the simultaneous precipitation of albumin or be mistaken for it. In some cases therefore a known amount of Triurol was mixed with urine and the mixture studied for its reaction to Heller's test and the boiling test. With a contrast concentration of 6 mg/ml or less, flocculation did not occur, 7 mg/ml gave a slight, and 8 mg/ml or more, a positive flocculation. In all of these cases the boiling test was negative. In order to form a clearer opinion of the amount of contrast medium in the urine during the first few days after renal angiography, the concentration of Triurol in the urine was determined in 23 cases. At angiography the patients had received 20 to 30 ml Triurol 47 to 52 % according to bodyweight. The first sample collected after angiography was found to contain 6.1 to 39.4 mg Triurol/ml urine. In the case with the lowest Triurol content, Heller's test was positive and the boiling test showed slight flocculation, but this patient had also had spells of albuminuria before angiography. In all of the other cases the urine contained more than 9 mg/ml, *i. e.* flocculation occurred on addition of nitric acid. The day after the injection the Triurol content was lower than 6 mg/ml in 12 cases, in 2 cases about 7 mg/ml, and in 7 cases more than 10 mg/ml. The highest value, 27.5, was recorded in a case of renal tumour, in which the angiography was not satisfactory and was therefore repeated a month later; the concentration of Triurol the following day was then 14.4 mg/ml urine. In 3 similar cases the concentration was 14.4, 14.2, and 12.5, respectively. In 2 cases of hydronephrosis and a stricture at the pelvo-ureteric junction, the concentration was 11.3 and 10.9 mg/ml, respectively. In the first case ordinary roentgenograms showed that the urine in the dilated pelvis contained contrast medium. Of the remaining 2 patients with more than 6 mg Triurol/ml urine, one had a tumour while the other showed no signs of a pathologic condition. Thus, a high percentage of false positives in Heller's test must be expected the day after renal angiography. Two days after angiography the urine contained only small amounts of contrast medium; on no occasion was it sufficient to give a false positive Heller's test.

In the further investigation of the effect of contrast medium on the result of Heller's test, samples of urine from 41 patients free from albu-

minuria before urography were tested for their reaction to Heller's test after the examination (20 ml contrast medium 35 %). The day after urography Heller's test was positive in 1 case and weakly positive in another, but the following day both were again negative.

In view of the foregoing, albuminuria was said to be present only when Heller's test was positive on at least 2 days after angiography, unless the reaction had been positive before the roentgenologic examination. This does not, however, necessarily infer the absence of albuminuria in those cases in which Heller's reaction was positive on one day only. It is therefore possible that the number of cases classed as positive in Table 1 is fictitiously low.

Cylindruria. In the examination of the urinary sediment special attention was directed to the occurrence of cylinders, these casts often dominating the histologic picture in animal experiments (IDBOHRN & BERG 1954). The number of cases examined was 171. Of the 106 cases in which Umbradil 60 % was used a few single cylinders were seen in 13 and a slightly larger number of cylinders in 1. Of the 49 cases in which Triurol 47 to 52 % was used isolated cylinders were seen in 3. In both groups the cylindruria was transient and never persisted more than a few days.

Size of kidneys. At operation for a floating kidney 3 to 4 days after excretory urography with Diodrast, PEIRCE (1953) found the kidney to be markedly hyperemic even when at urography the kidney had shown normal excretion of the contrast medium. He expressed the opinion that the change was due to a chemical inflammatory reaction. Since the observation of the renal enlargement after angiography in our Case 1, routine conventional roentgenograms of the kidneys have been taken in 88 cases. In 4 patients examined with Umbradil 60 % and in 5 with Triurol one or both of the kidneys showed an increase of about 1 to 1.5 cm in length or breadth. In one, however, with hydronephrosis due to an aberrant vessel and examined with Umbradil 60 %, the hydronephrotic kidney had increased from $>$ 14.5 cm by 7 cm to 18 cm by 8 cm the day after the examination. The markedly dilated pelvis and calyces contained contrast medium from the day before. On the next day the kidney was 15.5 cm by $<$ 7.5 cm and on the third day the enlargement had disappeared. In all of the 9 cases recorded the increase was only seen on one or two occasions and cannot be regarded as definitely pathologic.

Comments

Since 1951 it has been possible gradually to decrease the amount of contrast medium used for renal angiography. The transradial method required 1.0 to 1.1 ml of Umbradil 60 % per kg bodyweight. The transfemoral technique with retrograde injection permits a more selective

filling of the renal arteries and thereby a reduction in the dose of contrast medium to 0.6 to 0.7 ml/kg bodyweight. Since the introduction of sodium acetrizoate, in which the molecule has 3 iodine atoms — in diodone it has only 2 — it has been possible to reduce the dose still more, namely to 0.4 to 0.5 ml/kg. In order to evaluate the part played by the *amount* of contrast medium in the development of post-angiographic renal injury in the two largest groups with the same contrast medium (Umbradil 60 % transradially and transfemorally) the size of the dose used in cases with renal injury was compared with that used for those without. The difference found was only 0.1 ml/kg and probably insignificant.

In 22 of 164 examinations the patients received 2 injections of contrast medium, as a rule within 15 to 30 minutes. Of these 22, three belonged to the group of 32 patients with post-angiographic signs of disease, while the remaining 19 belonged to the group of 132 patients without signs of undesired reaction to angiography. In this material, then, the use of two injections per examination did not increase the frequency of renal injury. It should, however, be mentioned that in Case 2 the NPN increased moderately after 2 injections of Umbradil 60 % and that a previous investigation (IDBOHRN & BERG 1954) had shown that renal angiography, if repeated at short intervals, may cause damage to the kidney with a quantity of contrast medium too small in itself to cause renal injury.

In the investigation referred to (IDBOHRN & BERG 1954) Umbradil in a concentration of 17.5 % or more produced toxic injury to the kidneys, while Umbradil 10 % produced neither macroscopic nor microscopic changes. The maximum non-injurious concentration in these experiments lay somewhere between 10 and 17.5 %.

Comparison of the frequency of pathologic findings after the use of Umbradil 60 % with that after the use of Umbradil 50 % by one and the same technique (transradial) suggests the significance of the *concentration* of the contrast medium in renal angiography. The injection of Umbradil 60 % was followed by a slight increase in the NPN in 3 out of 39 cases, Heller's test was positive or weakly positive in 3 out of 39 cases, and in 8 out of 38 cases examined the urinary sediment contained isolated cylinders. Of these 39 patients, evidence of a pathologic post-angiographic change was seen in 11 (in 3 of these, 2 of the tests gave positive results). The injection of Umbradil 50 % was followed by a slight increase in the NPN in 2 out of 15 cases but in none of the cases was Heller's test positive and no cylinders were found in the urinary sediment. Although the material was small and the changes slight, it appears that an increase in the concentration of the contrast medium may involve an increased risk of renal injury.

Discussion and conclusions

It is apparent from the literature that renal angiography may involve a risk of injury to the kidneys. In some of the cases on record the doses of contrast medium used were as large as 40 ml to 70 ml (KUNLIN, BITRY-BOELY & VOLNIE 1950, MILLER, WYLIE & HINMAN 1954, THOMSEN & HANSEN 1954, LODIN & THORÉN 1955, and others), and the concentration was often high, ranging from 70 to 75 % (KUNLIN, BITRY-BOELY & VOLNIE 1950, MILLER, WYLIE & HINMAN 1954, THOMSEN & HANSEN 1954, JOSSELSON & KAPLAN 1954, in 3 of the 5 cases reported by ALWALL et coll. 1955, LODIN & THORÉN 1955, WEYDE 1955). The significance of the concentration of the contrast medium is also apparent from the experimental investigations of IDBOHRN & BERG (1954) who found no adverse effect of Umbradil (syn. diodrast) 10%, while Umbradil in a concentration of 17.5 % or higher was often followed by exudative and degenerative changes, which were, however, on the whole, reversible. Observations made in the present material also suggested that an increase in the concentration of the contrast medium involves the risk of side-effects on the kidneys.

Of importance for the concentration of the contrast medium in the kidneys is the site of its injection relative to the origins of the renal arteries. In three of the 7 cases described by MILLER, WYLIE & HINMAN (1954) in which the examination was attended by side-effects, and in the above-mentioned case of ARNESEN, BRUUSGAARD & WEYDE (1955), the contrast medium had been injected directly into one of the renal arteries or an aberrant vessel with consequent unilateral renal injury. In one of the cases reported by ALWALL et coll. (1955) in which the patient died, it was difficult to access the contributory role played by angiography because urography was performed on the same day and the tumourous kidney was excised as early as 3 days after angiography. It is probable that injury to the contralateral kidney in association with angiography was masked by compensatory function of the tumourous kidney, the function of which was good. Renal functional impairment appeared after the operation. More or less selective filling of one of the renal arteries was also seen in JOSSELSON's & KAPLAN's case, and in Case 1 of the present material, where the left kidney received a much larger proportion of the contrast medium than the right kidney.

The actual concentration of the medium in the renal arteries will of course also vary with the size of the dose injected into the aorta.

Two injections of contrast medium at only a short interval might have been partly responsible for the renal injury in some of the cases on record (MILLER, WYLIE & HINMAN 1954, RICHES & GRIFFITHS 1955, ALWALL et coll. 1955, WEYDE 1955, and in Case 2 of the present ma-

terial). Experimental evidence (IDBOHRN & BERG 1954) also suggests that repeated injections of contrast medium within a few days will increase the frequency of renal injury.

In renal angiography the technique employed should be such as to minimise the risk of injecting the contrast medium directly into the renal artery. For this purpose the catheterization method seems to be the method of choice although it is more time-consuming than the translumbar. In addition it must be regarded as unjustified to try to obtain good filling of the renal vessels by large amounts and high concentration of contrast medium. The tolerance of the kidneys to the agent injected for renal angiography varies widely from one case to another as shown by IDBOHRN & BERG 1954 in experimental investigations. Although the tolerance in clinical angiography is usually high, the maximum dose of the substance should not exceed the inferior level of tolerance. The diagnosis should be established by a more refined technique permitting a reduction in the size as well as the concentration of the contrast medium. In the present material the best results were obtained with Triurol 50 % injected transfemorally, but the series is not large enough to permit valid conclusions.

It is of importance to assess renal function before submitting a patient to renal angiography. Since 1951, when renal angiography began to be used more frequently in the Department, we have performed renal angiography only after the total renal function of both sides taken together has proved satisfactory; we recommend determination not only of the NPN, but also of the maximal concentration capacity of the kidneys, which should be at least 1.020.

SUMMARY

After a survey of cases in the literature in which side-effects of renal angiography were ascribed to the contrast medium, the results are given of certain functional tests carried out before and after angiography in a series of 200 cases. It is stressed that renal function should be satisfactory before the performance of renal angiography and that the technique should be such as to minimise the risk of injecting an amount and concentration of contrast medium calculated for the aorta into one renal artery, both these being kept as low as reasonably compatible with diagnostic requirements.

ZUSAMMENFASSUNG

Nach einem Überblick über die Fälle in der Literatur, bei denen Nebenwirkungen bei der renalen Angiographie dem Kontrastmittel zugeschrieben wurden, teilt der Verfasser die Ergebnisse gewisser funktioneller Proben mit, die vor und nach der Angiographie bei 200 Fällen ausgeführt worden sind. Es wird hervorgehoben, dass die Technik bei der renalen Angiographie so sein sollte, dass das Risiko, eine für die Aorta bestimmte Menge und Konzentration eines Kontrastmittels in eine Nierenarterie zu injizieren, auf ein Minimum reduziert wird.

RÉSUMÉ

Après une revue de cas publiés dans la littérature où des incidents de l'angiographie rénale ont été imputés au produit de contraste, l'auteur donne les résultats de certains tests fonctionnels effectués avant et après l'angiographie sur une série de 200 cas. L'auteur insiste sur le fait que l'angiographie rénale et sa technique doivent réduire au minimum le risque d'injecter dans une artère rénale une quantité et une concentration de produit de contraste calculées pour l'aorte.

REFERENCES

Alwall, N., Johnsson, S., Tornberg, A. & Werkö, L.: Acute renal failure following angiography especially the risk of repeated examination, revealed by eight cases (two deaths). Acta chir. Scandinav. 109 (1955), 11.

Arnesen, K., Bruusgaard, C. & Weyde, R.: Personal communication 1955.

Berry, N. E., White, E. P. & Metcalfe, J. O.: Abdominal aortography in urology. Canad. M. A. J. 66 (1952), 215.

Denstad, T.: Abdominal aortography. Acta radiol. 38 (1952), 187.

Doss, K. A.: Discussion to Hooks & Graves. South. M. J. 45 (1952), 591.

Hamm, F. C. & Harlin, H. C.: Perirenal insufflation with arteriography. J. Urol. 70 (1953), 318.

Harvard, M.: Renal angiography. J. Urol. 70 (1953), 15.

Hodes, Ph. J., Campoy, F., Riggs, H. E. & Blay, P.: Cerebral angiography. Fundamentals in anatomy and physiology. Am. J. Roentgenol. 70 (1953), 61.

Hooks, Ch. & Graves, O. H.: Experiences with percutaneous transfemoral renal arteriography. South. M. J. 45 (1952), 587.

Idbohrn, H. & Berg, N. O.: On the tolerance of the rabbit's kidney to contrast media in renal angiography. A roentgenologic and histologic investigation. Acta radiol. 42 (1954), 121.

Johnsson, S. & Norrman, T.: Lower nephron nephrosis efter renal angiografi. (Swedish.) Nord. med. 52 (1954), 1188.

Josselson, A. J. & Kaplan, J. H.: Fatal reaction following aortography with neoiopax. J. Urol. 72 (1954), 256.

Kunlin, J., Bitry-Boely, C. & Volnie, B.: Remarques sur l'aortographie. Rev. de chir. 88 (1950), 286.

Larsson, H. & Palmlöv, A.: Abdominal aortography with special reference to its complications. Acta radiol. 38 (1952), 111.

Lindblom, K. & Seldinger, S. I.: Renal angiography as compared with renal puncture in the diagnosis of cysts and tumours. Dixième Congrès de la Soc. Internat. d'Urol. Athènes I (1955), 331.

Lindgren, E.: Technique of abdominal aortography. Acta radiol. 39 (1953), 205.

Lodin, H. & Thorén, L.: Renal function following aortography carried out under ganglionic block. Acta radiol. 43 (1955), 345.

Löfgren, F. O.: Renal tumour not demonstrable by urography but shown by renal angiography. Acta radiol. 42 (1954), 300.

Maluf, N. S. R. & Mc Coy, C. B.: Translumbar aortography as a diagnostic procedure in urology with notes on caval phlebography. Am. J. Roentgenol. 73 (1955), 533.

Miller, G. M., Wylie, E. J. & Hinman, F. Jr.: Renal complications from aortography. Surgery 35 (1954), 885.

Olsson, Olle: Renal angiography. Dixième Congrès de la Soc. Internat. d'Urol. Athènes I (1955), 298.

Peirce, C. B.: Discussion to Hodes et coll. Am. J. Roentgenol. 70 (1953), 92.
Poutasse, E. F., Engel, W. J. & Root, J. C.: Translumbar aortography. Cleveland Clin. Quart. 19 (1952), 105.
Riches, E. W. & Griffiths, I. H.: Renal angiography. Dixième Congrès de la Soc. Internat. d'Urol. Athènes I (1955), 271.
Ritter, J. S.: Aortography. J. Urol. 73 (1955), 155.
Smith, P. G.: A résumé of the experience in the making of 1,500 renal angiograms. J. Urol. 70 (1953), 328.
Smith, P. G., Evans, A. T., Elsey, E. C. & Felson, B.: Translumbar arteriography, its roentgenologic interpretation. Am. J. Roentgenol. 67 (1952), 183.
Smith, P. G., Rush, T. W. & Evans, A. T.: An evaluation of translumbar arteriography. J. Urol. 65 (1951), 911.
Thomsen, G. & Hansen, T.: Abdominal aortografi. Teknik og diagnostiske erfaringer på grundlag af 32 tilfaelde. (Danish.) Ugeskr. f. Laeger 116 (1954), 369.
Trautner, K. & Pahle, H.: Renal arteriografi a. m. Peirce. (Danish.) Ugeskr. f. Laeger 116 (1954), 381.
Weyde, R.: Personal communication 1955.

FROM THE RADIUM CENTRE (DIRECTOR: PROF. JENS NIELSEN), COPENHAGEN, DENMARK

ROENTGEN SARCOMA

Report of a Case

by

Vera Andersen

Of the malignant tumours which may arise in the skin as a late complication of radiotherapy and of which carcinomas form the predominant majority, sarcomas are rare. Of the 21 patients with irradiation cancer reported by OLAF PETERSEN (7) from the Radium Centre, Copenhagen, for the period 1913—1952 only two had sarcoma. Since then, another case of irradiation sarcoma has been observed.

Case report

A woman, aged 55, was referred to the Radium Centre in March 1954. In 1920 she had received roentgen therapy during 4 sittings at monthly intervals for moist eruption on the hands. The condition was of four months' standing. It improved after the treatment, but as residues persisted, the patient had numerous and frequent roentgen treatments, the last in 1923; dosage unknown. The irradiation had caused swelling and ulcerations of both hands. In 1936 the patient was admitted to the Dermatologic Department of the Finsen Institute for severe roentgen dermatitis complicated by eczema of the dorsal aspects of the hands and fingers. During the subsequent years, she often had eczema and minor ulcerations in the irradiation scars, these being periodically treated in the same department until 1950. In 1951 an ulceration on the dorsum of the left hand commenced to proliferate. Despite treatment with ointments and Finsen light, the lesion increased slowly and steadily until in February 1954 the dermatologist removed a biopsy specimen which revealed polymorphocellular sarcoma, and the patient was referred to the Radium Centre. Clinical examination on 3 March 1954 (Fig. 1) showed severe irradiation lesions of the dorsa of both hands and the dorsal aspects of the fingers with atrophy, shrinkage, disturbances of pigmentation, and telangiectases. On the back of the left hand there was a prominent, reddish, fairly smooth tumour, measuring 3.5 × 4.5 cm. It was fixed to the underlying tendons and bones. The fingers, especially of the left hand, were gnarled and stiff owing to shrinkage of the skin. No palpable lymph nodes. Roentgen examination

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Fig. 1. Large elevated tumour on dorsum of left hand 31 years after discontinuation of prolonged roentgen irradiation. Dorsal aspects of hands and fingers show atrophic irradiation changes.

showed swelling of the soft tissues on the dorsal aspect of the left hand,but no destructive changes. Chest radiography revealed no abnormality. Following a surgical conference, amputation was advised as, owing to the extent of the tumour, this was considered the only possible treatment. On 9 April 1954, the left forearm was amputated (18 cm below the olecranon process) in the Department of Surgical Tuberculosis of the Finsen Institute. Follow-up examination in March 1955 showed no signs of recurrence; no ulceration of the right hand. Chest radiography again showed no abnormality.

Report upon a microscopic examination of biopsy specimen prior to operation: Ulcerated tumour tissue made up of dense bundles and strands of practically spindle-shaped mesenchymal cells. In places, the tissue is extremely cellular, the cells being densely arranged but in others interspersed with collagenous fibrils. The cells show typical polymorphism, and the nuclei striking variations in shape, size, and staining capacity; a few are poor in chromatin and clear, others being dark and with ample chromatin. In some regions there are several nuclei in each cell and, in a few, even large clumps of nuclei. It is this varying nuclear picture and the monstrous accumulations of nuclei which are extremely suggestive of myogenous sarcoma. No neurogenous structures in palisade arrangement. This is a case of polymorphocellular sarcoma with numerous spindle-shaped cells. There is no evidence that the tumour is producing bony tissue (Carl Deden).

Microscopic examination of the tumour after operation (Figs. 2 and 3): From an ulcerated surface the tumour spreads outwards beneath the adjacent stratified squamous epithelium as well as deep down, in several situations into the underlying connective and fibrous tissue. The tendon proper does not appear to be invaded, but the tumour tissue reaches at any rate as deep as the tendon. As regards the histologic appearance proper, there is not much to add, but it may be appropriate to emphasize that the polymorphism and nuclear abnormalities and large irregular clumps of nuclei are extremely well marked.

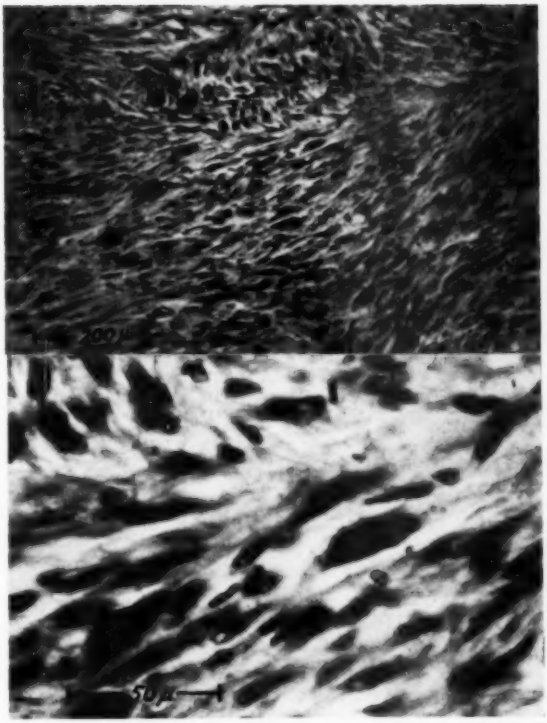

Fig. 2. *Top:* Section through the tumour: polymorphocellular fibrosarcoma (× 95).
Fig. 3. *Bottom:* Same as Fig. 2, high-power view (× 450).

The invasive nature is beyond doubt, the tumour tissue extending between surrounding strands of stroma and fibrils. Supplementary Mallory staining shows the vast number of fibrils to be blue which indicates *fibrosarcoma* (CARL DEDEN).

The predominant majority of roentgen sarcomas of the skin have arisen as a complication of irradiation therapy of lupus vulgaris. In 1939, DEUTICKE (2) reviewed the previously published irradiation sarcomas. Of these, 27 affected skin which had been irradiated for lupus vulgaris, whereas only 9 had arisen in skin exposed to heavy irradiation for other reasons. The latter group thus makes up only one quarter of all reported cases. In this connection it is worth mentioning that sarcoma may, though more rarely, also be a complication of non-irradiated lupus vulgaris.

In the present case the irradiation had been administered for morbid skin lesions. BOEHMER (1) has reported a sarcoma developing 17 years after roentgen irradiation for psoriasis of the hands, treatment which had been continued for 4 years. SAUERBRUCH (9) has published the case of a boy who developed sarcoma of the scalp following roentgen irradiation for trichophytide. WILSON & BRUNSCHWIG's (10) patient developed spindle-cell sarcoma 3 years after intensive roentgen irradiation of a thermal keloid of the chest wall.

Morbid cutaneous changes prior to the institution of roentgen therapy are, however, by no means a *sine qua non* for the development of sarcoma in skin damaged by irradiation. Disregarding the relatively large group of lupus sarcoma, the literature contains a considerably larger number of cases in which roentgen sarcoma has arisen in skin which had been healthy prior to irradiation. One of OLAF PETERSEN's (7) two patients with sarcoma had had, for experimental reasons, repeated roentgen examinations of the elbow which had resulted in severe irradiation damage. Forty-one years later, she developed ulceration in the same site which on microscopic examination proved to be a fibrosarcoma. KAPLAN (5) and VON MOOS (6) have reported one case each of sarcoma arising as a late complication of roentgen therapy for hypertrichosis.

Patients irradiated for more deep-seated lesions may also develop sarcoma of the damaged skin. JAYES & DALE (3), in 1951, described a spindle-cell sarcoma which developed on the neck 30 years after roentgen irradiation for Graves' disease. Later, PETTIT, CHAMNESS & ACKERMAN (8) published a similar case with fibrosarcoma. Others have reported sarcomas of the skin of the neck with irradiation damage. DEUTICKE (2) had a patient who had received irradiation directed at the nape of the neck following operation for a spinal tumour. OLAF PETERSEN's second case of sarcoma had 21 years previously been treated for enlarged cervical lymph nodes. In other regions too, sarcoma has been seen to develop as a late complication following roentgen therapy. JONES' (4) patient had a sarcoma which developed in the skin over the sacral bone 7 years after roentgen irradiation of a bladder papilloma.

In the majority of cases, as in ours, little information can be gleaned regarding the irradiation, the dose and quality of rays seldom being known. Often, the patients have had numerous courses of treatment which, with intervals, have frequently extended over a long period — even several years as in the present case. It is therefore impossible to give any threshold value for a sarcomatogenous dose; at any rate it must be high enough to induce chronic atrophic radiodermatitis.

The reported period from roentgen therapy to the development of roentgen sarcoma varies. The shortest interval seems to be 3 years, whereas in most cases it is much longer. In our case, 31 years had elapsed

from the last roentgen treatment until sarcoma was diagnosed. This is not an unusually long interval, as other cases have had a similar latent period. The longest reported interval is 41 years.

The treatment of roentgen sarcoma is surgical. Local excision is seldom sufficient, extensive surgical intervention usually being necessary to remove the tumour radically. This has frequently been impracticable, especially where the tumour has been situated in the head or neck.

In recent years, a relatively larger number of roentgen sarcomas has been reported than previously. PETTIT, CHAMNESS & ACKERMAN (8), for instance, have reported 4 cases diagnosed during the period 1950—1951. Considering the often very long interval between roentgen therapy and the development of roentgen sarcoma, this is not particularly striking. A number of the treatments, which have later given rise to sarcoma in the damaged skin, were administered at a time when radiotherapy was far from its present standard. Within a limited number of years, it is reasonable to expect that roentgen sarcoma will become even more uncommon than it is to-day.

My thanks are due to Professor P. V. MARCUSSEN of the Department of Dermatology, and to JOHS. MEYER of the Department of Surgical Tuberculosis, Finsen Institute, for permission to peruse the case records.

SUMMARY

A case of sarcoma developing in skin severely damaged by roentgen irradiation is reported. The literature on this condition is surveyed and discussed.

ZUSAMMENFASSUNG

Ein Fall wird berichtet, in dem ein Sarkom in einer durch Röntgenstrahlen schwer geschädigten Haut entstanden ist. Die Litteratur über dieses Leiden wird durchgegangen und diskutiert.

RÉSUMÉ

Présentation d'un cas de sarcome évoluant sur une peau gravement lésée par irradiation roentgen. Revue et discussion de la littérature sur cette affection.

REFERENCES

1. BOEHMER, L.: Über zwei Fälle von Sarkom auf röntgenbehandelter Haut. Arch. f. Dermat. u. Syph. 164 (1931), 106.
2. DEUTICKE, P.: Über Röntgensarkome. Beitr. z. klin. Chir. 169 (1939), 214.
3. JAYES, P. H. & DALE, R. H.: Sarcoma following X-ray therapy for Graves' disease. Brit. J. plast. Surg. 4 (1951), 147.
4. JONES, A.: Irradiation sarcoma. Brit. J. Radiol. 26 (1953), 273.

5. KAPLAN, I.: Sarcoma of cheek following Tricho X-ray treatment for hair on face. J. A. M. A. 102 (1934), 595.
6. MOOS, F. VON: Hautsarkom nach Röntgenbestrahlung. Schweiz. med. Wchnschr. 82 (1952), 179.
7. PETERSEN, O.: Radiation cancer. Acta radiol. 42 (1954), 221.
8. PETTIT, V. D., CHAMNESS, J. T. & ACKERMAN, L. V.: Fibromatosis and fibrosarcoma following irradiation therapy. Cancer 7 (1954), 149.
9. SAUERBRUCH, F.: Röntgensarkom. Fortschr. Röntgenstr. 31 (1923), 317.
10. WILSON, H. & BRUNSCHWIG, A.: Irradiation sarcoma. Surgery 2 (1937), 607.

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MEASUREMENTS OF ELECTRON DENSITIES WITH THE AID OF THE COMPTON SCATTERING PROCESS

by

Erik Odeblad and *Åke Norhagen*

The discovery by COMPTON (1923) of the inelastic collision between a photon and an electron has been of very great importance for pure and applied physics. One of the possibilities opened by this discovery is the measurement of electron densities in different materials by recording the intensity of the scattered gamma radiation.

Theoretical

Assuming the effects of binding energy of atomic electrons to be of negligible importance, the differential cross-section, σ, per electron for the Compton scattering process has been given by KLEIN and NISHINA (1929):

$$\sigma = \sigma_1 \cdot \frac{1 + b^2}{(1 + q - qb)^2}\left[1 + \frac{q^2(1 - b)^2}{(1 + b^2)(1 + q - qb)}\right] \quad \ldots\ldots\ldots\ldots \quad (1)$$

where $q = E/mc^2$, E being the energy of the primary gamma ray and mc^2 the rest energy of electron. $b = \cos v$, v being the scattering angle. $\sigma_1 = e^4/2(mc^2)^2$, e being the electronic charge. For a scattering angle of $\pi/2$, eq. (1) may be reduced to

$$\sigma_{\pi/2} = \sigma_1\left[\frac{1}{(1 + q)^2} + \frac{q^2}{(1 + q)^3}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

If the measurement of scattering is undertaken at a fixed angle, and a fixed intensity and energy of incident radiation, the intensity of scattered radiation depends solely on the number of electrons in the scattering specimen. Consequently, at a fixed scattering volume, it would be possible to measure the electron density M (number of electrons per cm^3). The absolute measurement of electron density would be difficult, but the measurement relatively to a substance with known electron density very easy, as the energy

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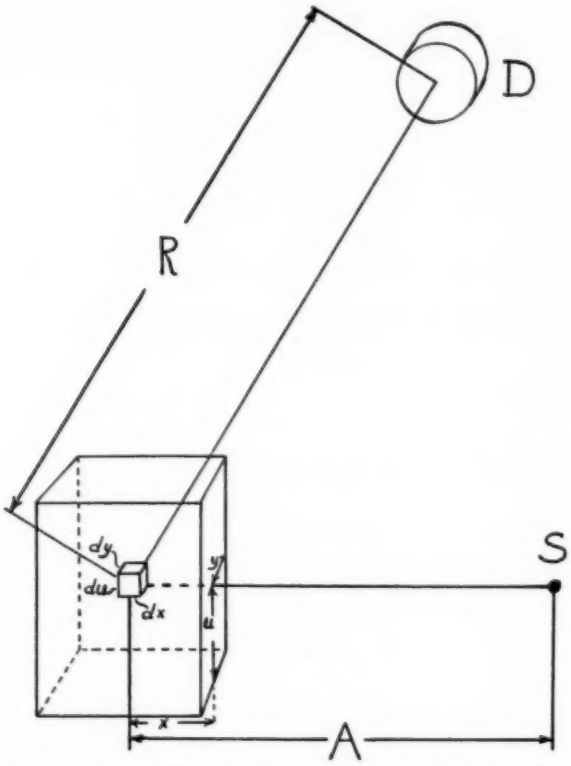

Fig. 1. Outline of experimental arrangement. Source of gamma radiation, S, is placed at distance A from scattering element $dxdydu$. Perpendicular distance to detecting crystal D is R. x, y and u denote distance of scattering element from surfaces of scatterer.

of the scattered radiation depends only on the scattering angle (E constant) making this relative measurement independent of energy based upon detector efficiency.

The energy of the scattered gamma ray, E', is given by the eq.

$$E' = E/(1 + q - qb) \quad \ldots\ldots (3)$$

or, at the angle $\pi/2$:

$$E'_{\pi/2} = E/(1 + q). \quad \ldots\ldots (4)$$

Let us now consider a scattering element $dxdydu$ (Fig. 1), situated at the distances x, y, and u, from the surfaces of a scattering specimen as indicated. The solid angle relations for the gamma radiation from a source of strength S (millicurie) gives for the number of primary gamma quanta per second on the element $dxdydu$:

$$d^2I = 3.7 \cdot 10^7 \; S \; (dydu/4\pi A^2) \; e^{-\mu x} \quad \ldots\ldots (5)$$

A is here the distance between source and scattering element, and μ the total absorption coefficient of the primary gamma radiation.

Using the definition formula for cross-section we obtain the intensity of scattered radiation per unit solid angle:

$$d^2I = d^2IM\sigma dx, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

M being the number of electrons per cm³ of scatterer.

The solid angle in steradians for the detection of secondary gamma radiation is W/R^2, W being the area of the scintillating crystal and R the distance between scattering element and crystal. Taking the solid angle and absorption of secondary gamma rays into consideration, we can write for the counting rate C:

$$d^2C = d^2I\,\varepsilon\,(W/R^2)\,e^{-\mu' y}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

ε being the efficiency of the crystal-photomultiplier-discriminator system in feeding pulses to the scaler. μ' is the total absorption coefficient of secondary gamma rays.

Combining eq. (5), (6) and (7) we obtain by integration (if $x, y, u < A, R$):

$$C = 3.7\ 10^7\ SM\,\sigma\,\varepsilon\,(W/4\pi R^2A^2)\int_0^X e^{-\mu x}dx\int_0^Y e^{-\mu' y}dy\int_0^U du \quad \ldots\ldots\ldots\ldots \quad (8)$$

Extending this equation to a complex scatterer, we write ΣNZ for M, N being number of atoms of charge Z per cm³ of scatter. Extending eq. (8) to a complex gamma spectrum of source with multiplicity q for each gamma ray we may write:

$$C = 3.7\ 10^7\ SU\,(W/4\pi A^2R^2)\ (\Sigma NZ)\left(\Sigma\frac{\varepsilon\,q\sigma}{\mu\mu'}\right)(1-u^{-\mu X})\ (1-e^{-\mu' Y}) \ldots\ldots \quad (9)$$

where X, Y, and U, are the dimensions of a parallel-epipedic scatterer. If X, Y, and U, are comparatively small we may write

$$C = 3.7\ 10^7\ S\,XYU\,(W/4\pi A^2R^2)\,(\Sigma NZ)\,(\Sigma\,\varepsilon\,q\sigma) \quad \ldots\ldots\ldots\ldots\ldots \quad (10)$$

If we compare two scatterers under otherwise constant conditions we have, accordingly:

$$C_a/C_b = (\Sigma NZ)_a/(\Sigma NZ)_b \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

i. e. the counting rates are proportional to the electron densities.

Multiple Compton scattering chains do not contribute substantially in our experiments because $M\sigma X$, $M\sigma Y$ and $M\sigma U < 1$.

Experimental

A twenty millicurie Co^{60} radiator was the source of primary gamma rays and enabled the use of a very constant incoming flux of radiation. The distance A between the source and the specimen was between 12 and 20 cm and the distance R between the specimen and the detector between 16 and 24 cm in different experiments. The examined scattering volume, XYU, was usually about 2 cm³. The sample was enclosed in a glass container. The mean scattering angle was 90° ($\pi/2$). The energies of the incident gamma rays were 1.17 and 1.33 MeV. Heavy lead-shielding collimated the incident and secondary beams and protected the detector from the primary gamma flux. A commercial scintillation detector was used.

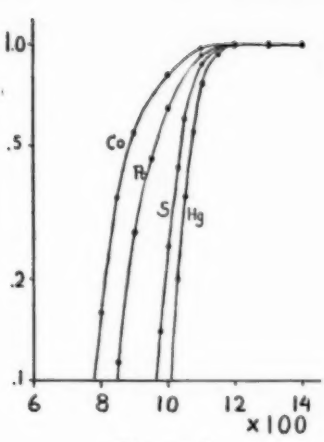

Diagram 1

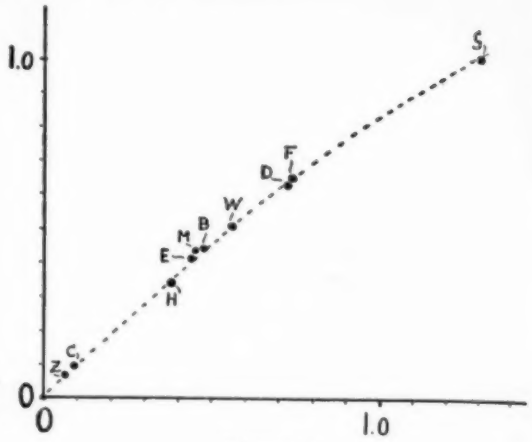

Diagram 2

Diagram 1. Counting rates (in units of maximum counting rate) at different voltages (abscissa) for Co^{60} gamma radiation (Co), Po^{210} gamma radiation (Po), Compton-scattered radiation at angle $\pi/2$ for Co^{60} (S) and Hg^{203} gamma radiation (Hg). Energies of standard gamma radiations are: Co^{60}, 1.17 and 1.33 MeV, Po^{210}, 0.80 MeV and Hg^{203}, 0.28 MeV.

Diagram 2. Relation between intensity of scattered radiation (ordinate, unit 10^4 counts per min above background) and electron density (abscissa, unit: density X atomic number/atomic weight) for various substances. Z = zellstoff, C = cotton, H = n-hexan, E = ethyl alcohol, M = methyl alcohol, B = benzene, W = water, D = monobrombenzene, F = chloroform, G = bromine (liquid). Same geometric conditions used in all measurements.

In performing measurements the instrumental background with the empty glass container in place (when used) was measured repeatedly. Various samples were introduced in the container and counted. About 10^5 impulses were usually counted. The voltage of the photomultiplier was generally 1,100 volts (see Diagram 1).

Results

1. *Influence of voltage of photomultiplier.* The influence of the voltage on the counting rate of scattered radiation is shown in Diagram 1. Interpolation between known gamma emitters gives a value of about 0.35 MeV for the scattered radiation. According to eq. (4) it should be 0.33 MeV.

2. *Measurement of the differential cross-section.* Using water ($\Sigma NZ = 3.4 \cdot 10^{23}$ cm^{-3}. of 2.4 ml volume and assuming the cross-sections for the two gamma rays of Co^{60} to be 95 and 88 resp., 10^{-28} cm^2/steradian for $\pi/2$ scattering angle and $\varepsilon = 0.60$ for both of the scattered gamma rays, we obtain for $W = 1.2$ cm^2, $A = 12$ cm and $B = 16$ cm, that is

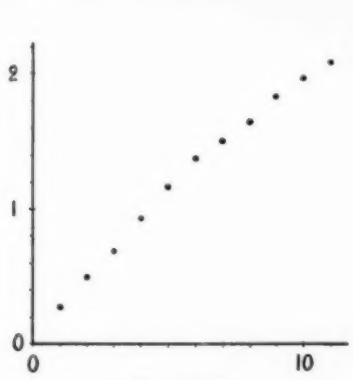

Diagram 3

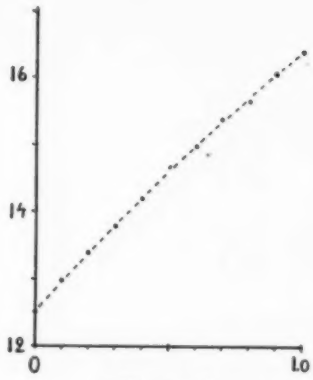

Diagram 4

Diagram 3. Relation between intensity of scattered radiation (ordinate, unity: 10^4 counts per min above background) and number of scattering brass foils (abscissa). Geometry different from that used in Diagram 2.

Diagram 4. Relation between intensity of scattered radiation (ordinate, unity 10^3 counts per min. above background) and volume-fraction of monobrombenzene in benzene (abscissa). Geometry different from that used in Diagrams 2 and 3.

43 ± 4 counts per sec should be obtained in the detector. The experimental value was 46 ± 1, giving $(\sigma_1 + \sigma_2) = (160 \pm 20) \cdot 10^{-28}$ cm²/steradian, in good agreement with theory.

3. *Relation between electron density and relative scattering intensity.* Substances of known electron density were investigated. The results are given in Diagram 2 together with the theoretical curve according to eq. (9), normalized to water.

4. *Relation between sample volume and relative scattering intensity.* Brass foils were stacked and used as scatterers. The results are shown in Diagram 3. The linear relation, with deviation downwards due to self-absorption of scattered radiation within the specimen, is shown.

5. *Effect of isotopic composition of specimen.* Common water and 99 per cent D_2O were investigated. The values were $10{,}150 \pm 120$ and $10{,}070 \pm 115$ in several runs, indicating that no effect of isotopic composition was present, as expected.

6. *Applications to mixtures of benzene and monobrombenzene.* The results, shown in Diagram 4, indicate a definite relation between volume fraction of monobrombenzene in benzene and counting rate.

7. *Application to some biologic specimens.* The results are shown in Table 1. As expected the intensity of scattered radiation from lung tissue varied with the pathologic condition present.

Table I

Relative intensities of scattered radiation in some in vitro experiments

Specimen	Rel. intensity
Dist. water	1.00
Liver	1.04
Fat tissue	0.85
Lung, upper normal lobe	0.66
Lung, emphysema	0.45
Lung, hypostasis	0.80
Lung, atelectasis	1.04

8. *Application to human tissues in vivo.* Volunteers were placed in the equipment, rearranged for measurements in human subjects. Some results are shown in Table II. Although the collimation of the beam was not as good as might have been possible, the results are in the directions expected. The dose delivered to the small piece of tissue examined was 50 milliroentgen (maximum) per measurement.

Table II

Relative intensities of scattered radiation in some measurements in vivo

Specimen	Rel. intensity
Dist. water	1.00
Subject I, lung	0.55
Subject II, lung	0.62
Subject I, knee	1.22

Discussion

The present experiments indicate that a 20 millicurie Co^{60} radiator may be used to produce Compton-scattered radiation of enough intensity to measure the electron density in specimens of the order of size of a few cm^3. The applications exemplified indicate that several applications are possible in physics, chemistry, biology, and medicine. Work is proceeding in our laboratory to measure the electron densities in various parts of diseases lung tissue *in vitro* and *in vivo*.

Since the factor (ΣNZ) is involved in the stopping formula for charged particles in matter, the measurement of this quantity experimentally is of very great importance when activation analysis with charged particles is performed on specimens of unknown general composition. This will be discussed later in a paper on activation analysis with charged particles (ODEBLAD 1956).

SUMMARY

The Compton-scattering of gamma rays has been applied to measurement of electron densities in different materials. Some theoretical views and experimental data are presented. Various applications in physics, chemistry, biology, and medicine, are exemplified and discussed.

ZUSAMMENFASSUNG

Die Compton-Streuung der Gamma-Strahlen wurde für die Messung der Elektronendichte verschiedener Stoffe verwendet. Einige theoretische Betrachtungen und experimentelle Resultate werden vorgelegt. Verschiedene Anwendungen in der Physik, Chemie, Biologie und Medizin werden exemplifiiert und besprochen.

RÉSUMÉ

La diffusion des rayons gamma par effet Compton a été appliquée à la mesure de la densité des électrons dans diverses substances. Les auteurs présentent des résultats théoriques et des données expérimentales. Ils donnent des exemples de diverses applications en physique, en chimie, en biologie et en médecine.

REFERENCES

Compton, A. H.: A quantum theory of the scattering of X-rays by light elements. Phys. Rev. 21 (1923), 482.

Klein, O. and Nishina, Y.: Über die Streuung von Strahlung durch freie Elektronen nach der neuen relativistischen Quantendynamik von Dirac. Ztschr. f. Physik 52 (1929), 853.

Odeblad, E.: Activation analysis with charged particles. Will be published in Acta radiol.

BOOK REVIEW

DIE RÖNTGEN-UNTERSUCHUNG DES HERZENS UND DER GROSSEN GEFÄSSE. Von R. Janker, F. Grosse-Brockhoff, R. Haubrich, H. Lotzkes, A. Schaede, H. Hallerbach. 222 S., 248 Abb. Verlag W. Girardet, Wuppertal-Elberfeld 1955. DM. 34: 50.

The lectures dealing with the roentgen examination of the heart and great vessels which formed the subject of the first course of instruction at Bonn are now presented in book form. This is the first of a series dealing with various fields of roentgen diagnosis and therapy and based upon future courses of instruction.

JANKER opens the book with a chapter (37 pages) devoted to different roentgen methods; a general survey of tomography (including transverse tomography), kymography, serial photography, and cineroentgenography, is included. The various possibilities of the two latter examinations are discussed in detail, reflecting the author's great interest and own contributions in this sphere. He emphasizes the importance of keeping the dosage of radiation both on the patient and operator as low as possible in these examinations.

In the chapter (50 pages) which follows, GROSSE-BROCKHOFF makes a comparison between the clinical and electrocardiographic findings on the one hand and the roentgenographic on the other. A short introduction to the relation between hemodynamics and changes in the shape of the heart is followed by a description of various groups of heart diseases with the above viewpoints in mind. The survey covers pericardial affections, primary myocardial damage (aneurysms after infarction, acute and chronic myocardial dilatation) and injuries due to overload — *Überlastungsschäden* — (arteriovenous fistulae, congenital and acquired defects, hypertension).

HAUBRICH in his comprehensive chapter on electrokymography (45 pages) first presents a historical outline of the method and describes the technique and gives suitable means of carrying out the examination in various cardiac affections. The author points out the importance of the method being used with discretion.

In the next chapter (5 pages), LOTZKES discusses practical methods of performing catheterization of the heart, as well as angiocardiography and thoracic aortography. The routine views in these examinations consist of a cinematographic record upon 35 or 70 mm film in the frontal projection and 30 × 30 cm roentgenograms (3 per sec) in the lateral.

Indications for and findings in catheterization of the heart, angiocardiography, and thoracic aortography in various groups of congenital and acquired cardiac defects are dealed with by SCHAEDE in a chapter of 28 pages.

HALLERBACH in her chapter (37 pages) discusses the importance of carrying out the examination of the heart in a suitable manner, that is to say, of employing the correct method for arriving at a definite diagnosis in the simplest and safest way; consideration must be given to the necessity of diminishing the radiation dose as much as possible. The course of an investigation of a heart is illustrated with several examples and the differential diagnosis discussed from the viewpoint of the histories and clinical findings.

The book terminates with several lines by JANKER in which he points out the advantages of the technique of cineroentgenography from the viewpoints of diagnostics, didactics, and research.

As a whole, the book is of the highest typographic class, extremely well written and, by reason of the uniformly fine quality of the numerous illustrations, easy to read. Every chapter ends with its individual summary although because of its nature the book contains no references. The contents to a great extent are representative of the roentgen diagnostics of the heart of the Bonn school but as far as the reviewer is able to judge reflect most of the latest international experiences. For all those who desire rapid initiation into this realm as it stands today the book is extremely well worth reading.

H. Lodin.